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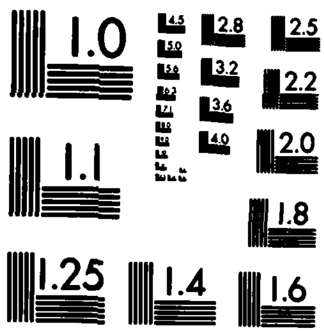

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REPRESENTATION OF SMALL-ARMS EFFECTS IN
AGGREGATED FORCE-ON-FORCE COMBAT MODELS

by

Lawrence B. Lane

March, 1984

Thesis Advisor: J. G. Taylor

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This thesis explores the problem of determining the relative worth of small-arms in a combined arms scenario by using aggregated models. The documentation of current operational models is reviewed to see how the effects of small-arms have been represented in general, and in large scale aggregated-force models in particular. After investigation of the main uses of small-arms, an inference is drawn that the contribution of small-arms is only implied in current models.

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Representation of Small-Arms Effects in Aggregated Force-on-Force Combat Models

by

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Submitted in partial fulfillment of the requirements for the degree of

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ABSTRACT

This thesis explores the problem of determining the relative worth of small-arms in a combined arms scenario by using aggregated models. The documentation of current operational models is reviewed to see how the effects of small-arms have been represented in general, and in large-scale aggregated-force models in particular. After investigation of the main uses of small-arms, an inference is drawn that the contribution of small-arms is only implied in current models.

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I. INTRODUCTION

This thesis was motivated by a seminar presented to the Operations Research Curriculum of the Naval Postgraduate School in August of 1983. The representative of the Joint Service Small Arms Program (JSSAP) of the Armament Research and Development Center expressed a need for showing small-arms as a force multiplier in a combined arms scenario of modern combat. The perception was that small arms were not represented in theater-level models used in defense studies.

It is the hypothesis of this thesis that small-arms are a main tool for controlling combat. A lack of understanding on the correct use and the effects of small-arms is every bit as detrimental on today's modern battlefield as it was in past wars, perhaps even more so with the devistating consequences awaiting one who makes mistakes when his adversary has the advanced weapons systems of today.

With an increased use of modern computers to simulate combat for defense studies, it is imperative that one understand all of the complexities of the combat he is trying to simulate. Defense acquisition is relying more and more on computer aids for weapons procurement. One had better be aware of any assumptions or drawbacks of a computer aided decision before making a decision on where to put emphasis in what weapons are neeeded.

The initial intent of this thesis was to provide a concrete analysis on the value of small-arms as a force multiplier represented in aggregated-force models. (Small-arms, as used in this thesis, is a general term used to denote weapons of a pistol, rifle, or machine gun nature.) There are two interelated problems in determining the relative worth of small-arms in a combined-arms scenario: 1) what is the contribution of small-arms to modern combat (and how does one go about quantifying it)? and 2) in light of (1), how does one go about representing the effects of small-arms in combat models in general and large-scale aggregated-force models in particular?

Weapons, weapon systems, tactics, and war itself have undergone continual evolution since the dawn of time. The analysis on the use of weapons in combat took a dramatic change in the early 1960's with the introduction of the scientific method to evaluate defense policy and planning.

With weapon systems becoming increasingly complex and budgetary considerations taking a front row seat, Secretary of Defense McNamara instituted the "Modern Design for Defense Decision." His remarks indicated a need to evaluate the overall goal and capability of the whole defense posture of the United States and then break this down into the individual contributions of different units and weapon systems with a keen eye on effectiveness per dollar. [Ref. 1: p.32]

This basis has prompted a large number of models to be the foundation for quantitative studies. The Department of Defense estimates an annual cost of about a quarter of a billion dollars on quantitative studies with thirty to forty million alone for new models [Ref. 2].

The Soviets also have a deep interest in the use of combat models for military studies. They consider combined arms combat to be the operation of a system composed of subunits of the combined arms team. Through this medium the Soviets are attempting to model the complexities of combat in a realistic manner. [Ref. 3]

Table I depicts a general outline of the use of quantitative studies in the Soviet Union. [Ref. 4]

The Soviet Union has used operations research techniques to study virtually all aspects of combat. A leading topic in

TABLE I

SOVIET USES OF OPERATIONS RESEARCH

1. Off-Line Support of Weapons-System Acquisition Process
   - Design of new weapons systems
   - Development of "optimal" tactics for new weapons systems
   - Development of "optimal" countermeasures against new enemy weapons systems
2. On-Line Support of Combat Operations (Automated Troop Control)

Soviet studies is that of modelling what they term troop control. Their troop control closely parallels what is referred to as command and control in the United States. We are also very interested in the modelling of the command and control processes. [Ref. 5: p.313]

Modelling the command and control function of defense forces is a process that models combat at the largest of scales. Smaller submodels are needed to drive the larger command and control processes. Command and control can be described as the process which allocates resources. Command is the term used by military authority to allocate or reallocate assigned resources. Control, on the other hand, is the process by which that allocation takes place. [Ref. 6: p.5] Figure 1.1 is an illustration of a simple command and control process. [Ref. 7]

A methodology for identifying deficiencies and alternative solutions in the command and control process involves the need for assessment of current and projected capability and reflects the projected growth in the appropriate threat [Ref. 6: p.11]. Chapter III explores the processes of combat that must be modelled to accurately assess the capability of one force against another. These processes are the foundation for comparing and deciding in the command and control process.

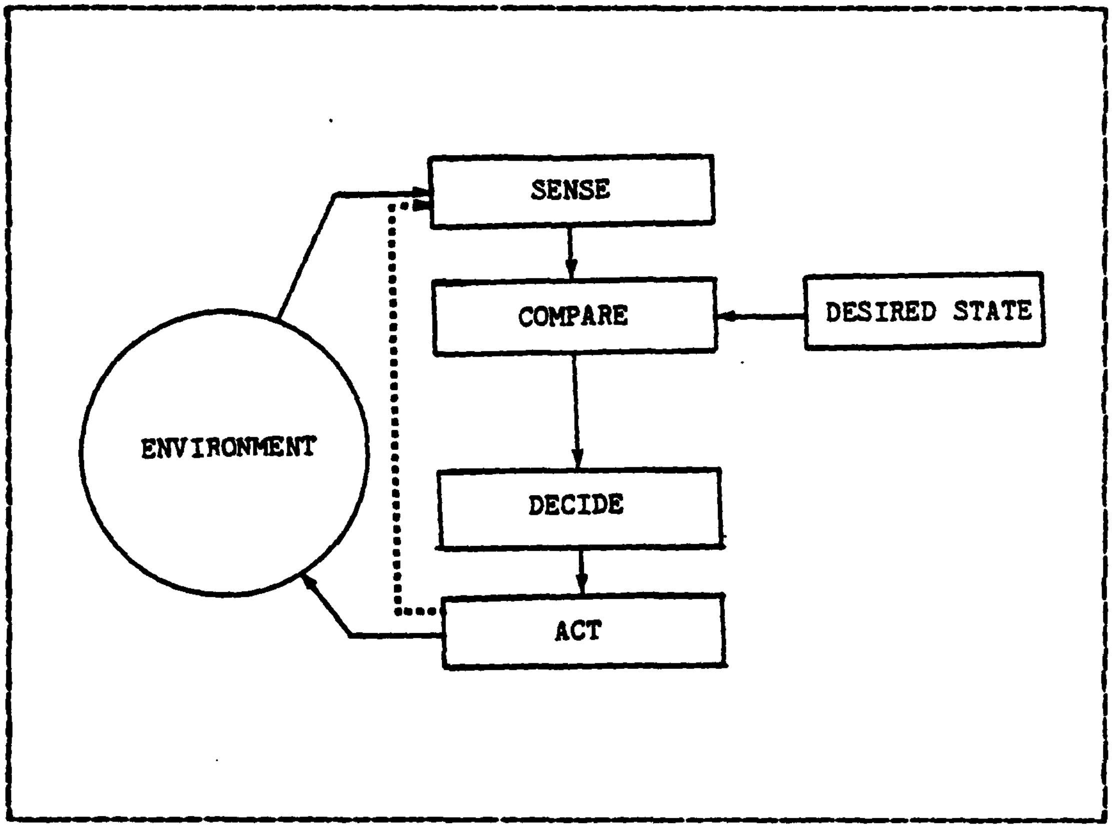


Figure 1.1 THE COMMAND AND CONTROL PROCESS.

JSSAP's impressions that combat models are not truly representative of the interaction of small-arms in combat are by no means unique. In its report to Congress the Government Accounting Office states:

> It should be apparent that if attrition and the synergistic effects of lower level combat were truly understood, there would not be such a disparity in the modelling of theater-level attriton. Conversely, to the extent that these things are not well understood--the analytical basis for assessing weapon system effectiveness appears to warrant continuing attention [Ref. 1: p.148].

Dr. F.B. Kapper, the former Scientific and Technical Advisor for the Organization, Joint Chiefs of Staff, remarks:

The phenomonology of combat, as far as I'm concerned, is not as well understood as it needs to be. In all honesty I don't think we fully understand the interaction of combined arms. Take a typical ground force situation, with one guy looking at it. Now someone introduces all kinds of air/ground interdiction and then it gets somewhat complex. Then someone puts in some tactical nuclear or chemical munitions and that really creates complexities that I really don't think we understand. I think we should try to look at the basic phenomena and try to get a better handle on the essentials. I don't think we do enough in this regard [Ref. 8].

After some initial research, it became apparent the solution of the problems pointed out in the above quotes and the problem mentioned earlier of quantifying the contribution of small-arms to modern combat was well beyond the scope of this thesis. With very little in the way of published research on the dynamics of combat and its modelling available, a concrete solution on the value of small-arms became even harder. By exploring the basics of attrition in combat models and reviewing the main uses of small-arms in combat, it is the intention of the thesis to present a framework for inferring how the contribution of small-arms to modern combat is implicitly represented for current models.

Chapter II will investigate the current need for small-arms on the modern battlefield. With the missions of small-arms as a foundation, methods of combat modelling will be reviewed to see why the effects of small-arms are not fully represented. Chapter III will present an overview of model types. This background is important for understanding how and why models are developed and what their purpose is. Chapter IV explores the basics of attrition modelling. While small-arms play only a small role in direct attrition, they are responsible for other larger weapons systems being able to achieve kills. Chapter V investigates the attrition methodcgy of IDAGAM, a near current aggregated-force model. Again, small-arms are a small part in direct attrition but attrition is the foundation for modelling the combat dynamics of movement where the effects of small-arms is most apparent. The last two chapters bring together these concepts to show the importance of small-arms and how this importance is implicit rather than explicit in aggregated models.

II. EMPLOYMENT OF SMALL ARMS ON THE MODERN BATTLEFIELD

A background on the missions of small-arms is important for understanding that their major effects are not in the actual attrition or killing of the enemy but in how they are used to control the battle. Small-arms are at the very heart of combat yet their vital effects are sometimes overshadowed by the larger weapons sytems. This chapter, based on experiences at the National Training Center at Ft. Irwin California, will show how small-arms are vital to making the larger weapons systems as valuable as they are.

It is a common and also intuitively obvious assertion that the tank is the most 'valuable' weapon system in the ground battle. What is not quite as commonly known or remembered is that the tank is a part of a combined arms team, supporting the infantry, whose mission is to "Locate, Close With, and Destroy the Enemy by Fire and Maneuver." Tanks by themselves are of minimum value in a battle. Tanks, in conjunction with a balanced combined arms team of infantry, artillery, aircraft, and possibly naval gunfire, have a very high value.

> There is still a tendency in each separate unit...to be a one-handed puncher. By that I mean that the rifleman wants to shoot, the tanker to charge, the artilleryman to fire...that is not the way to win battles.
>
> -MG George S. Patton

The concept of a combined arms team is that the value of the team is greater than the sum of the individual components. The value of small arms must be thought of in a slightly different manner than tanks or artillery as small arms are inherent to every fighting unit, not just the infantry. The use of small arms as a tool for maintaining contact with the enemy in a close combat situation has not changed since the invention of black powder. Despite the increased range and lethality of modern weapons, the final stages of combat are still those of "eye to eye." The attacker's mission is still to eventually stand on the ground that the defender is currently on and doesn't intend on moving from. Other uses for small arms are created and evolve with the invention and evolution of other weapons systems and tactics.

Table II gives the main uses of small arms on the modern battlefield. This table was developed after interviewing mechanized infantry company commanders and evaluators from the National Training Center (NTC), reviewing the Army's Command and Staff College's observations on the NTC exercises, and the author's personal experiences as a Marine and instructor at the U.S. Army Field Artillery School at Ft Sill, Oklahoma. Table II is not intended as an all inclusive list of uses of small arms. The intent is to give the reader a feel for the interaction of small arms and an intuitive grasp of their value in a combined arms battle.

TABLE II

MAIN USES OF SMALL ARMS

1. MAINTAINING CONTACT/CLOSE COMBAT
2. DENY ACCESS TO TERRAIN
3. BREAK UP/ISOLATE OPPOSING FORCES AND VEHICLES
4. PREVENT DISMOUNTED INFANTRY FROM CLEARING OBSTACLES
5. SECURITY OF FORCES AND WEAPON SYSTEMS
6. RECONNAISANCE/COUNTER RECONNAISANCE
7. PERSONNEL SAFETY

Note that for points in Table II, the uses of small-arms all seem to be related to the movement of the overall forces and not the attrition of individual soldiers or weapons. The remainder of the chapter will discuss the dynamics of how small-arms accomplishes the tasks enumerated in Table II

A. STRATEGY OF COMBAT

From the American perspective, Soviet doctrine for warfare in Europe is that of a rapid advance. Their offensive actions intend on bypassing strongpoints or a quick breakthrough if that is impossible. Their plans utilize an echelon concept for follow-on units to clean up strongholds. Through proper employment of front line units and well-placed obstacles protected by small arms fire, the NATO defense is to channelize their advance, break up their echelons, and isolate units from the main force. [Ref. 9]

The National Training Center (NTC) at Ft Irwin, California conducts live-fire combined-arms exercises throughout the year. NTC utilizes videotape and constant position locating equipment along with the Multiple Integrated Laser Evaluation System (MILES) for determining kills. The Center is not capable of assessing kills due to small arms but they do play a role in the exercises. Obstacles are a key to slowing down and channelizing an attacking force. When obstacles are encountered, infantry are required to dismount and clear them. Machine gun and rifle fire prevent the clearing, or at least slow it down. Consider a situation in which a tank or personnel carrier encounters an obstacle. If the defender is properly employed, the vehicle will be taking fire. The obstacle must be moved or the vehicle will be destroyed. Infantry dismount and attempt to clear the obstacle under the direction of the vehicle commander who is competing with rifle fire directed at the infantry for the attention of the man. If a large machine gun is penetrating the carrier, the command and control of the unit is disrupted. What has more impact; a sergeant or .50 caliber jacketed slugs tearing holes through a few inches of allusinum surrounding one? The extra time in the obstacles, brought about through small arms fire, increases the probability of kill for larger weapons due to more acquisition time and time for more rounds to be fired.

On the other side of the coin, small arms bring about protection from antitank guided missiles. If an antitank weapon has a certain probabilty of kill in a non-opposed situation, that probability is certainly degraded by suppression from small arms fire, even if a kill of the weapon is not achieved. [1] Infantry and small-arms drive out individuals with antitank (AT) weapons. Regardless of whether or not the weapon is destroyed, the unit moving against the AT weapons is able to move faster and further than if the AT weapons were at their full effectiveness.

A heavy combat unit, such as a tank company in the defense, can be destroyed by a numerically smaller force of antitank weapons if the tank company does not properly employ its organic small arms in a viable security plan. There is sometimes a tendency in armor and artillery units to go lax on security measures and the result is that a small, lightly armed opposing force is able to destroy or highly degrade them. [2]

----

[1]These conclusions and observations were drawn from conversations with LTC. J.C. Crowley of the Trends section of the Combined Arms Center at Ft. Leavenworth, Kansas. See appendix A for a complete view of how small arms and infantry are integrated into the combined arms team at the National Training Center.

[2]These observations are taken from conversations with Captain R. Hirlinger, an Armor Task Force Observer-Controller at the National Training Center, Ft Irwin, California. See appendix A for further discussion.

Artillery units not only need good security while actually delivering fires, but during movement to other positions. The invention of counter battery radar forced a doctrinal change on the artillery of requiring several moves a day. During these moves the artillery pieces are of little value but they are highly vulnerable to attack from light infantry units. Their only means of surviving to use their high combat value is through effective use of organic small-arms.

An artillery weapons system is composed of three parts; the howitzers themselves, a fire direction center, and some means of observing and directing the fires, normally a foward observer. The foward observer is employed with the front line units to locate and adjust fires on targets. He relies on small arms for his survival. Even if he never engages an enemy with his personal weapon, his bold and agressive surveilance of the battlefield would be hampered if he did not have the means to protect himself. Likewise, an enemy would be more aggressive in his actions to take out the observer if he was aware that the observer was inadequately protected. Psychology plays a big role here. Who would be more apt to confidently adjust artillery fires or call in air strikes in a hostile jungle environment-a soldier who has a heavy M-14 rifle with limited ammo because of its weight or his adversary with an AK-47 capable of rapid rates of accurate fire? The argument for the long-range kill capability of the M-14 is valid, the point here is that the weapon must be the best for the job. Long-range kills in a jungle are few and far between but the knowledge that your weapon is better suited for the task at hand than the enemy's is of great importance not only in contact but in attitude.

Reconnaisance is a big key in the command and control of combat units. Where are the enemy strongholds? How many enemy are there? What types of weapons does the enemy have? These questions are answered in part by actual manned patrols. As is the case with the foward observer, these patrols rely on small-arms for their protection and aggressive actions. The opposition also employs patrols. The key to insuring a good defensive plan is preventing the enemy from defeating it through the use of his reconnaisance. Small-arms play the largest role in this counter reconnaisance scenario. How close would an enemy infantryman look for obstacles if he was aware that his helmet was balanced on the front post of an opposing rifle? How effective would he be if the rifle delivered accurate fire on the target?

B. VALUE OF SMALL-ARMS TO LARGE UNITS

Based on the above examples, figure 2.1 is an intuitive approach to the value of the organic small arms in say, an artillery battery or tank company. Naturally, a unit with no small arms may easily become the target of light infantry infiltrators. With no means to protect itself the battery or company could readily be destroyed or degraded. A unit with, say twice the table of organization and equipment (TOE) in small arms normally assigned to it would not gain much overall value as too many personnel would be required to man the smaller weapons and manning of the larger weapons would suffer. More effective small-arms would enable more weapons to increase the value of a unit without the expense of added personnel.

C. ESSENCE OF COMBAT

Many good studies have been made on command and control countermeasures and counter countermeasures (C3CM), but they tend to focus on the technical aspects of jamming and improved and special munitions delivered by aircraft and

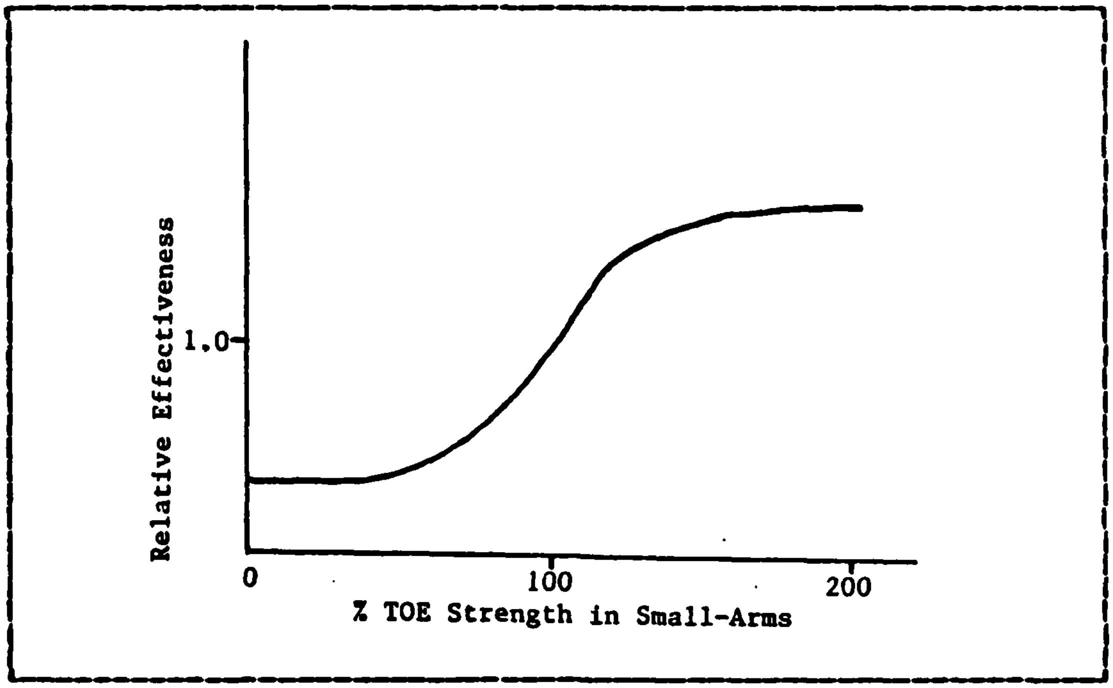


Figure 2.1 SMALL ARMS IN OVERALL VALUE OF UNIT.

artillery. One of the primary mission of the Soviet Union's special forces or "diversionary" troops is that of neutralizing command and control centers. These "Spetsnaz" units are elite, special trained soldiers who infiltrate deep into the enemy rear areas to disrupt and destroy. The defense against such actions is for the operators of the command and control centers to be well trained in the use of small arms and for their commanders to insure that all personnel are aware that they are <u>soldiers first</u> and their specialty is in support of an overall combat action. [Ref. 10]

The effects of small-arms are not merely to kill infantrymen in an infantry on infantry battle. The major value of small-arms is their integraton into a tactically sound plan of a combined-arms team. It doesn't matter who obtains the kill, the important point is that weapons systems work together to meet an overall objective of victory with limited friendly casualties. Small-arms are as vital to this team as tanks, aircraft, or artillery.

III. OVERVIEW OF MODEL TYPES

Knowing why models are developed goes a long way in the understanding of what one can expect them to do. This short chapter gives an introduction in this regard and will prepare the reader for the actual concepts of attrition modelling presented in the following chapters.

Models are abstractions of reality. They are developed and used because their idealizations are easier than full-scale exercises to use in analysis due to far less complexity. The U.S. Army Models Review Committee defines a model as "an abstract representation of reality which is used for the purpose of prediction and to devlop an understanding about the real world processes" [Ref. 2: p.5].

Models are generally classified according to how they represent reality. Figure 3.1 shows the varying degrees with which combat representations portray reality. [Ref. 2: p.6] Field exercises, field experiments, and map exercises are more realistic but they are expensive, hard to control and take a great deal of preparation to set up. The more abstract models on the right can be run to give design to or a basis for a more operationally realistic model towards the left.

Wargames and open simulations use people in the loop to simulate combat decision processes, whereas closed simulations and analytical models use algorithms to represent decision processes. Simulations often use pseudo-random number generators to determine outcomes and are generally called Monte Carlo simulations. Analytic models are mathematical models and are ususally deterministic as opposed to the stochastic approach of using random numbers. [Ref. 2: p.6]

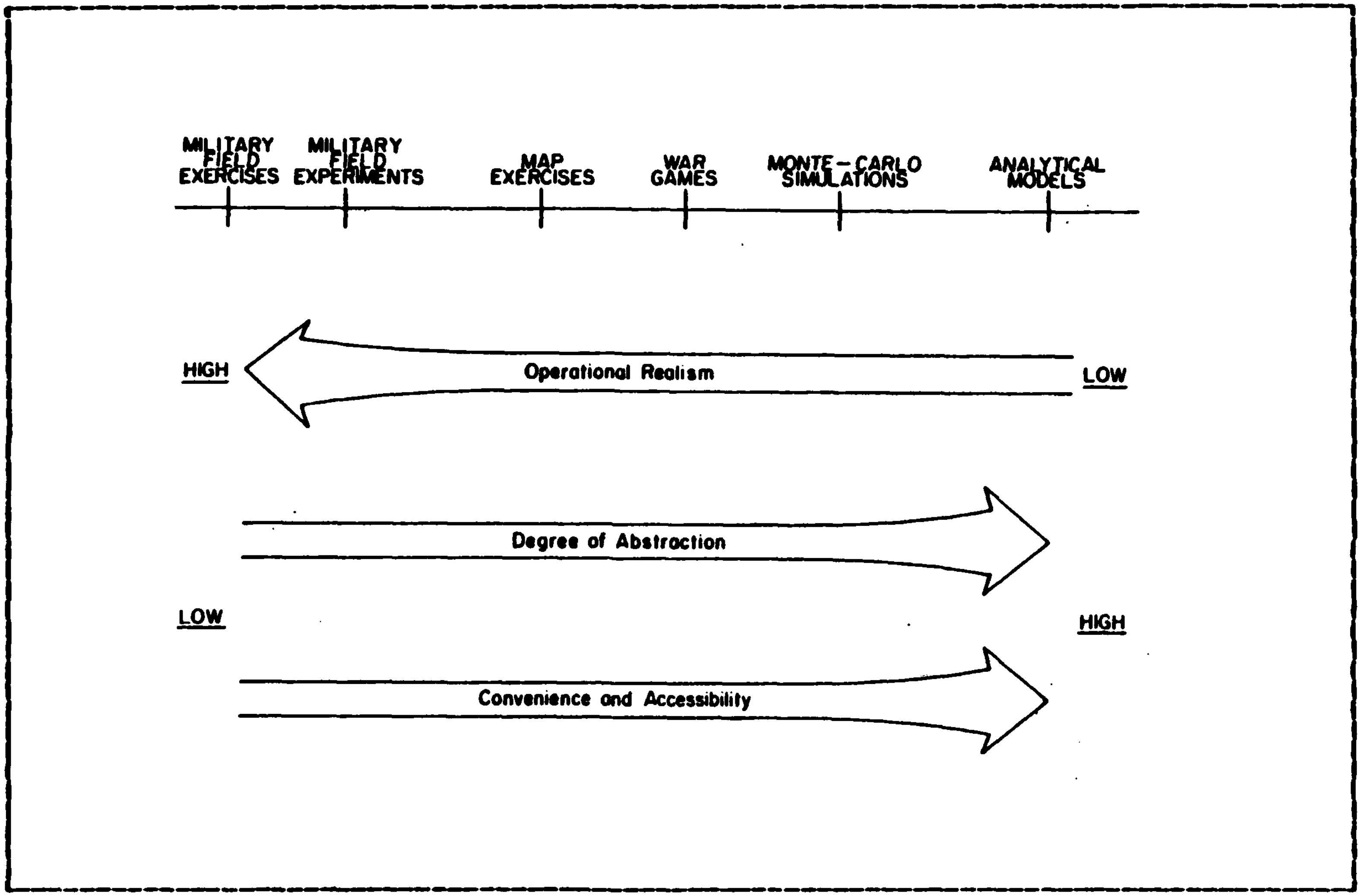


Figure 3.1 THE SPECTRUM OF TYPES OF COMBAT REPRESENTATIONS.

There is some discussion over the validity of deterministic versus stochastic models, but the conceptual methodology used in this thesis can be tailored to either type of approach. Although the models discussed in this thesis will be of the deterministic analytical type, their outcomes can be used as submodels of the more realistic simulations and wargames.

A simulation or wargame has to model many different aspects of combat in order to be a valuable tool for an analyst or military commander. Table II lists the major combat processes that must be considered [Ref. 11: p.66].

TABLE III

COMBAT PROCESSES

1. Attrition
2. Movement
3. C3 I (Command, Control, Communications and Intelligence)
4. Support

Movement of the Foward Edge of the Battle Area (FEBA), or as it is now called, the Foward Line of Troops (FLOT), is a function of many things including terrain trafficability and a force ratio of attacker to defender. The changing force ratio during combat is a direct function of the attrition process of both forces involved as well as movement against each other. This attriton to movement concept is an important point. As chapter II has pointed out, the value of small-arms is more in the movement phase but it will be shown that attrition is the underlying concept for current models.

As mentioned in Chapter I, the process of command and control involves comparing and deciding. This compare and decide phase compares strengths and weaknesses of both sides with an appropriate decision on how best to control the battle to an outcome favorable to the friendly side.

It is critical that the attrition process portrays a combat situation as realistically as possible. Attrition not only drives movement, but it is also the foundation of assessment of changing force capability that the commander relies on in his sense and compare states. The Mitre Corporation's Study on Command and Control Evaluation concludes with six remarks, two of which are appropriate here:

> There is a need to devlop simple analytic models to describe the current and projected capability of a military force to accomplish its assigned missions. The model should reflect the general nature and magnitude of an existing deficiency.
>
> Models could be useful in structuring/focussing the resource allocation debate in the Services and at high government levels. These models could identify information needs and determine contributions of proposed programs to mission accomplishment. [Ref. 6: p.66]

In a simulation, as in the real world, the commander needs feedback on his decisions. The assessment routines that rely on attrition are of paramount importance to a reallistic model. Attrition is only part of the overall combat process. But the need for the analyst of the wargame or simulation to understand the capabilities and drawbacks of the attrition processes used in his model cannot be overstressed.

The next chapter deals with different attrition aproaches used, starting with a simple Lanchester equation of combat. Conceptually it would be ideal to represent combat at the item to item level. This would involve portraying the results of one on one combat for each and every possible combination of friendly to enemy weapons engagements for all weapons available to either side. This would become very complex and somewhere along the way aggregation of forces becomes necessary. Aggregation yields an "overall combat effectiveness" of the force that is needed, if not for the model itself, for the commander's sensing and comparing of his capabilities against that of his opponent. The second half of Chapter IV deals with aggregation concepts.

IV. MODELLING THE FORCE-ON-FORCE ATTRITION PROCESS

Attrition modelling, or casualty assessment of some sort is one of the foundation processes of all combat models. By examination of these processes, one will be able to understand how the effects of small-arms discussed earlier are implied rather than openly used in the attrition processes. There are basically three approaches to casualty assessment: a Monte Carlo simulation, the firepower score, or a Lanchester-type model. Monte Carlo simulations are generally used for battalion-sized units and smaller engagements and hence will not be discussed further in this thesis. The firepower score approach is used in modelling theater-level combat and will be addressed in the second half of this chapter and in chapter V. Lanchester-type models have been developed in the United States for the full spectrum of combat from small units to theater level. [Ref. 2: p.12]

A. DETAILED LANCHESTER-TYPE MODELS

Frederick W. Lanchester's purpose in 1914 was to provide insight into the dynamics of combat under "modern conditons" and to justify the principle of concentration. His basic equations have been the foundation for virtually all differential equation approaches to combat modelling. Figure 4.1 depicts the basic Lanchester paradigm. [Ref. 12]

1. The Fundamental Lanchester-Type Attrition Paradigm

The combat in figure 4.1 is between two homogeneous forces: a homogeneous X force (for example, tanks) opposed by a homogeneous Y force (for example, anti-tank weapons). Lanchester's equation for modern warfare assumes that the

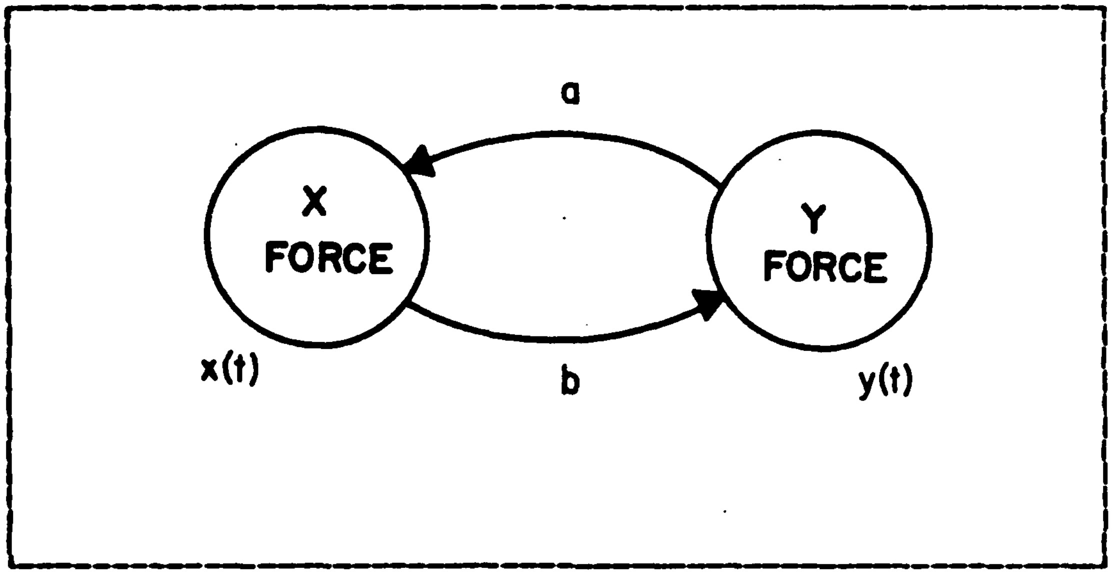


Figure 4.1 LANCHESTER COMBAT.

casualty rate of such a homogeneous force is directly proportional to the number of enemy firers. For example, the X force casualty rate is given by equation 4.1 where 'a' denotes the rate at which a single typical Y firer kills X targets and is called a Lanchester attriton-rate coefficient. X(t) and y(t) denote the numbers of X and Y combatants, respectively, at time t with x(0) = x and y(0) = y. [Ref. 13: p.8]

$$dx/dt = -ay \qquad \text{(eqn 4.1)}$$

Equation 4.1 was Lanchester's formulation of "modern warfare" and is referred to as the "aimed fire" law. The law of "ancient warfare" or "area fire" depicts the time rate of change of the X force as being proportional not only to the number of enemy firers, but also to the number of friendlies they have to fire upon. This is shown in equation 4.2.

$$dx/dt = -axy \qquad \text{(eqn 4.2)}$$

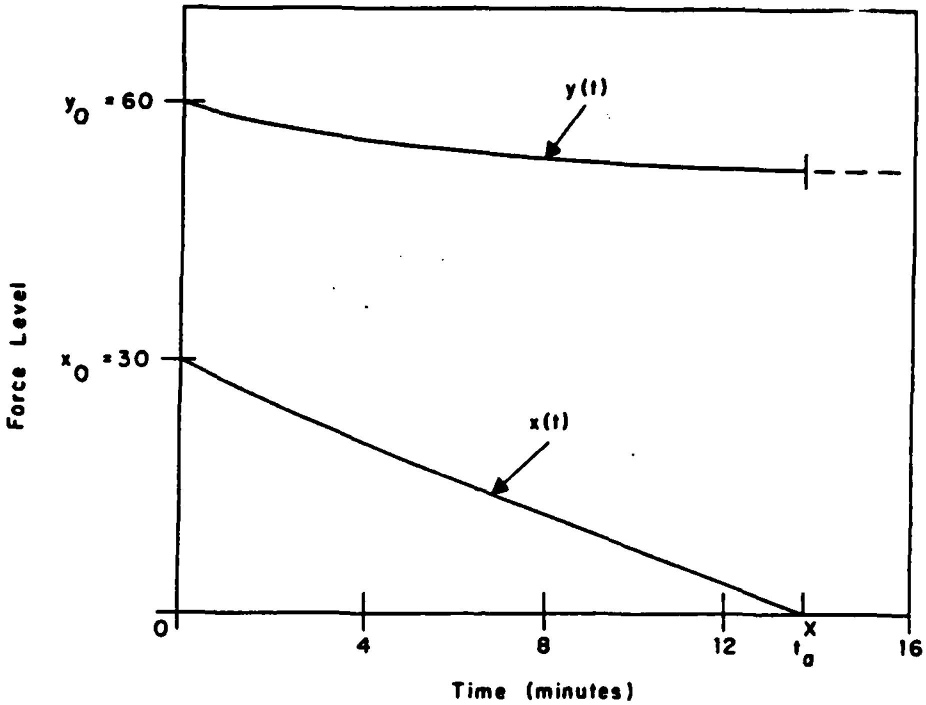
In both of the above two equations, it is assumed that both the X and Y force are greater than zero. That is to say that the casualty rate is equal to zero if the force size is equal to zero.

The casualty rate for the Y force in aimed fire to complement equation 4.1 is that $dy/dt = -bx$, where b denotes the rate at which a single typical X firer kills Y targets. These constant coefficient Lanchester-type equations for modern warfare lead to Lanchester's famous "square law" in equation 4.3. Equation 4.3 yields many important results. For example, X will win a fight to the finish if and only if $x_0/y_0 > \sqrt{a/b}$. The $\sqrt{ab}$ is known as the "intensity" of combat. Figure 4.2 graphs the X and Y force levels under modern combat. [Ref. 14: p.12]

$$b(x_0^2 - x^2) = a(y_0^2 - y^2) \qquad \text{(eqn 4.3)}$$

Lanchester's work in 1914 was insightful and helped prove the value of concentration of fire but there were shortcomings in his original model that needed looking at if we were to use his formulations today. Table IV lists these shortcomings. [Ref. 12: p.9]

Virtually all of the shortcomings listed in table IV have been addressed in some way or another by extensions to the Lanchester theory; some more adequately than others. For example, to model supressive effects it would seem easy enough to degrade or lower the attrition rate coefficient to reflect degraded fire effectiveness of the firing units. Unfortunately there is no supportable data on troop behavior when under fire to use in such a situation.



X and Y forces for combat modelled by constant-coefficient Lanchester-type equations for for modern warfare. As long as both X and Y>0, the force level x(t) is given by equation 4.4 For these calculations, a=0.04 x casualties/minute per y firer and b=0.04 y casualties/minute per x firer.

Figure 4.2 FORCE-LEVEL TRAJECTORIES.

$$x(t) = x_0 \cosh\sqrt{ab}\, t - y_0\sqrt{a/b}\, \sinh\sqrt{ab}\, t \qquad \text{(eqn 4.4)}$$

Although the U.S. Army Combat Developments Experimentation Command (CDEC) has conducted many supression experiments and the U.S. Army has reviewed the entire topic of fire suppression, the representation of suppressive effects in casualty-assessment models remains a major problem area [Ref. 2: p.73].

TABLE IV

SHORTCOMINGS OF ORIGINAL MODELS

1. COEFICIENTS CONSTANT OVER TIME (e.g. VARIATION OF WEAPON SYSTEM CAPABILITY WITH FORCE SEPARATION IGNORED)
2. NO MOVEMENT OF FORCES (e.g. ADVANCE OR RETREAT)
3. HOMOGENEOUS FORCES
4. BATTLE TERMINATION CONDITIONS NOT GIVEN
5. DETERMINISTIC, NOT PROBABILISTIC
6. NO REPLACEMENTS OR WITHDRAWLS
7. TARGET AQUISITION FORCE LEVEL INDEPENDENT
8. FIRE ALLOCATION NOT EXPLICITY CONSIDERED
9. SYMMETRIC
10. NO CONSIDERATION OF NONCOMBAT LOSSES (E.G. DESERTIONS, SURRENDERS)
11. NO LOGISTIC CONSIDERATIONS
12. NO WAY OF PREDICTING LANCHESTER ATTRITION-RATE COEFFICIENTS
13. SUPRESSIVE EFFECTS OF WEAPONS NOT CONSIDERED
14. EFFECTS OF TERRAIN NOT CONSIDERED
15. SPACIAL VARIAITONS IN FORCES NOT CONSIDERED

Suppressive effects is by no means the only controversial issue with attrition modelling. The very nature of the attrition coefficents is one topic worth discussion. Attrition rate coefficents all have a basis in historical extraction from past combat. Reconstruction of a combat situation is a difficult thing to do, and often important items are overlooked, but it is essentially the only means upon which to start the computations of attrition rate coefficents. Ammo expenditure for a past battle is compared to the number of kills achieved for that weapon then the scenario is looked at in terms of terrain, visibility, opposing weapons, and other factors to derive an attrition rate coefficient. These rates are then massaged for how the weapons of the past battle are perceived to be different from the present systems. It is apparent that the concept of selecting attrition rates is one requiring considerable, never ending effort. The rest of this half of the chapter on Lanchester equations will deal with generalized examples of extentions derived to counter the shortcomings listed in table IV.

Table V lists different functional forms for attrition rates that have been considered in the Lanchester combat theory literature. [Ref. 2: p.31]

TABLE V

FUNCTIONAL FORMS FOR LANCHESTER ATTRITION

ATTRITION PROCESS	DIFFERENTIAL EQUATIONS	STATE EQUATION
F|F	$dx/dt=-ax$ $dy/dt=-bx$	Lanchester (1914) $b(x - x) = a(y - y)$ Square Law
FT|FT	$dx/dt=-axy$ $dy/dt=-bxy$	Lanchester (1914) $b(x - x) = a(y - y)$ Linear Law
F|FT	$dx/dt=-ay$ $dy/dt=-bxy$	Brackney (1959) $b/2(x - x) = a(y - y)$ Mixed Law
T|T	$dx/dt=-ax$ $dy/dt=-by$	Peterson (1953) $b \ln(x/x) = a \ln(y/y$ Logarithmic Law
(F+T)|(F+T)	$dx/dt=-ay-Bx$ $dy/dt=-bx-Ay$	Morse and Kimball (1951) (generally very complicated)

Abreviations used to denote the form of Lanchester attrition under discussion are of the form F|FT where '|' is the dividing line between attacker and defender. The different combinations normally encountered are depicted in Table V. The square law and linear law have already been discussed briefly. The mixed law is a combination of these two which can be conceptualized as an ambush-type engagement, in which one side employs aimed fire and the ambushees use area fire, as they do not know the exact location of the ambushers. The logarithmic law is normally only used during the early stages of small-unit engagements, in which the vulnerability of a force dominates its ability to acquire enemy targets. (F+T)|(F+T) combat is, simply stated but very complex in practice, square law attrition between combatants with operation losses or losses due to supporting arms that are themselves not subject to attriton.

2. Helmbold's Extention

Helmbold hypothesized that a much larger force would fight less efficiently than a smaller opponent and introduced a modification that alters the attrition rate coefficients based on force ratio. Equation 4.5 and 4.6 show Helmbold modifications with a(t) and b(t) being the time dependent attriton-rate coefficents, and E_x and E_y denoting the fire effectiveness-modifications that model the inefficiencies of scale.

$$dx/dt = -a(t) * E_y(x/y) * y \quad \text{with } x(0) = X_0 \qquad \text{(eqn 4.5)}$$

$$dy/dt = -b(t) * E_x(y/x) * x \quad \text{with } y(0) = Y_0 \qquad \text{(eqn 4.6)}$$

Helmbold stated that his fire-effectiveness-modification factors should satisfy the following three requirements: [Ref. 2: p.37]

(R1) $E_x(u) = E_y(u)$ (i.e. same inefficiencies of scale for each side,

(R2) $E(u)$ is an increasing function of its argument,

(R3) $E(1)=1$

Helmbold considered the special case where his modification factors for scale were a power function, i.e.: $F(u)=u^c$ with c>0. In the case of constant attrition-rate coefficients, Helmbold equations then become equations 4.7 and 4.8. W is refered to as the "Weiss" parameter and W=1-C. When W=1, Helmbold reduces to the square law, when W=1/2, the linear law and when W=0, the result is the logarithmic law. [Ref. 2: p.39]

$$dx/dt = -a*(x/y)^{1-W}\ y \quad \text{with } x(0)=X_0 \qquad \text{(eqn 4.7)}$$

$$dy/dt = -b*(y/x)^{1-W}\ x \quad \text{with } y(0)=Y_0 \qquad \text{(eqn 4.8)}$$

It is valuable to look at the various attrition equations in terms of small-arms. Small-arms will seldom be used in the equations directly, their value comes in terms of how are the various parameters of the equations affected by small-arms. AT weapons attempt to kill tanks. How is the expected time to kill a tank affected when small arms are shooting at the AT weapon as opposed to when it is not. Although it is difficult to say numerically the difference, it is obvious the difference is there.

3. Determination of Attrition Rate Coefficients

Two approaches have been used in the United States for the determination of attrition rate coefficients. They are;

1) a statistical estimate based on "combat" data generated by a detailed Monte Carlo combat simulation.

2) an analytical submodel of the attrition process for the particular combination of firer and target types.

The first approach is known as a 'fitted parameter analytical model' since the attrition rate coefficients are statistically estimated from a Monte Carlo combat simulation. The second approach is known as a freestanding or 'independent analytical model.' Basically this second approach says the attriton rate coefficent is equal to the reciprocal of the expected time for an individual firer to kill a single target, as shown in equation 4.9. [Ref. 2: p.47] [3]

$$a = 1/E\left[T_{XY}\right] \qquad \text{(eqn 4.9)}$$

Table VI lists the parameters necessary for understanding the expected time to kill approach for determining Lanchester attrition-rate coefficents. [Ref. 2: p.51] With the definitions of table VI, the expected time for an individual firer to kill an enemy target is shown in equation 4.10.

Although equation 4.10 is a formidable looking expression, it does reduce nicely to intuitive appealing results with certain assumptions: 1) If the target acquisition time is negligible ($t = 0$), 2) the weapon has a uniform rate of fire ($t_l = t_h = t_m = 1/v$), 3) statistical independence among outcomes ($p = p(h|h) = p(h|m) = Pssk$), and 4) negligible time of flight ($t = 0$), equation 4.10 reduces to equation 4.11 where the single shot kill probability Pssk is given by $Pssk = Pssh * p(k|h)$.

This leads to the intuitively appealling result that the Lanchester attrition-rate coefficient is equal to the firng rate, v, of the weapon times the probability of a single shot kill by the weapon. [Ref. 2: p.52]

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[3] See reference 13: p.139 for justification for using the reciprocal of the expected time to kill a target as the Lanchester attriton-rate- coefficient.

TABLE VI

PARAMETERS IN EXPECTED TIME TO KILL EQUATION

Factors included in expression for Lanchester attriton-rate coefficient for single-shot Markov-dependent-fire weapon systems with a geometric distribution for the number of hits required for a kill.

TIME TO ACQUIRE A TARGET, t_a

TIME TO FIRE FIRST ROUND AFTER TARGET ACQUIRED, t_1

TIME TO FIRE A ROUND FOLLOWING A HIT, t_h

TIME TO FIRE A ROUND FOLLOWING A MISS, t_m

TIME OF FLIGHT OF THE PROJECTILE, t_f

PROBABILITY OF HIT ON FIRST ROUND, p

PROBABILITY OF A HIT ON A ROUND FOLLOWING A HIT, p(h|h)

PROBABILITY OF A HIT ON A ROUND FOLLOWING A MISS, p(h|m)

PROBABILITY OF DESTROYING A TARGET GIVEN IT IS A HIT, p(K|H)

$$E[T] = t_a + t_1 - t_h + \frac{(t_h + t_f)}{P(K|H)} + \frac{(t_m + t_f)}{P(h|m)} \left\{ \frac{[1 - P(h|h)]}{P(K|H)} + P(h|h) - p_1 \right\} \quad \text{(eqn 4.10)}$$

$$E\left[T_{kY}\right] = 1/(v_Y \, Pssk_{kY}) \quad \text{(eqn 4.11)}$$

$$a = v \, Pssk \quad \text{(eqn 4.12)}$$

The assumption of negligible target acquisition is a gross one for simplification. In reality, target acquisition time is a very important factor to be considered in operational models. Two basic approaches are used for target acquisition: 1) parallel acquisition, in which a firer continually searches for targets, even when engaging a target and 2) serial acquisition, in which one cannot acquire targets while engaging another target. *

Again, the data for these equations has a historical base with alterations from testing as possible. Probabilities of hitting and killing a target are controversial issues under different conditons but it is obvious that most all of the factors in the equations are affected indirectly by small-arms fire. The time to acquire the target is the job of the foward observer discussed in chapter II. If the observer and the personnel in the artillery position itself have good security with small-arms one can bet that the probability of a hit is higher due to factors such as a better target location, more accurate firing data determined by the fire direction center and a more precise lay of the howitzer itself by a crew free from the distraction of a harrassing sniper.

4. Heterogeneous Forces

The above mentioned concepts and equations are formulated for a homogeneous force. The concepts can be extended to apply to a combined arms scenario more in line with the operationally pertinent forces of today. For example, an X force composed of infantry, tanks, artillery, aircraft, and all the different weapons systems associated with them, would be more realistic on the modern battlefield. Figure 4.3 depicts a schematic of a heterogeneous force attrition model. [Ref. 13: p.16]

In examining figure 4.3, the X force has "m" weapon types and the Y force has "n" weapon types. The subscript i refers to the X force while the subscript j refers to the Y

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*See reference 13: pp.30-73 for a fairly complete look at the target acquisition process.

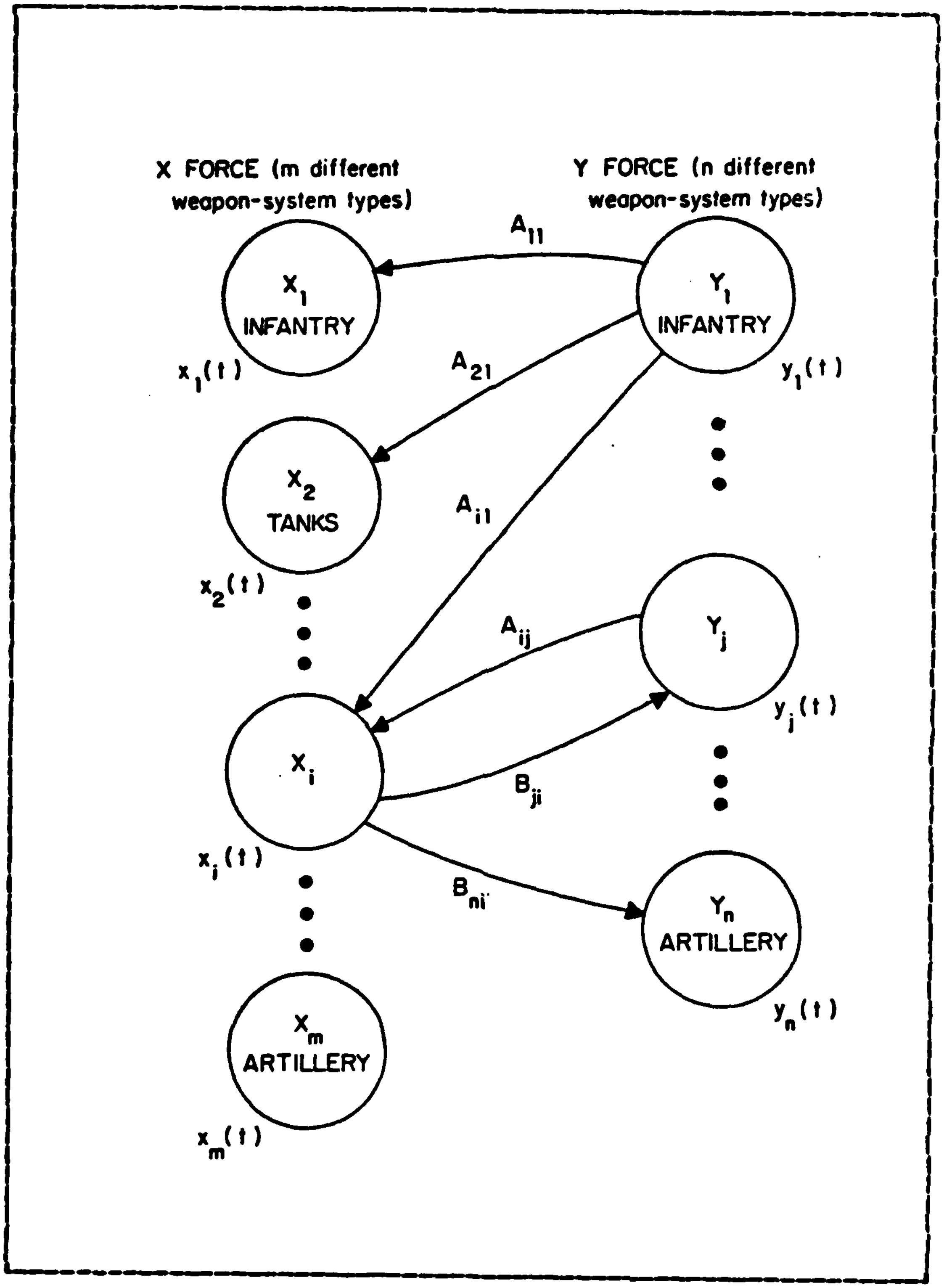

Figure 4.3 NOTATION FOR HETEROGENEOUS-FORCE COMBAT.

force. In the double subscripted attriton rates, the first subscript denotes the target type and the second subscript denotes the firer. A_{ij} denotes the rate at which a typical Y firer kills X targets in the oposssing enemy force. With these definitions, equation 4.13 defines the attriton rate for the individual ith weapon system of the X force. [Ref. 13: p.14]

$$dx_i/dt = -\sum_{j=1}^{n} A_{ij} \quad Y_j \qquad \text{(eqn 4.13)}$$

In a logical extention of homogeneous attriton rates, the heterogeneous attrition rates A_{ij} are given by equation 3.14 where $T_{X_i Y_j}$ = the time for a y_j firer type to kill an x target type.

$$A_{ij} = 1/\ E\left[T_{X_i Y_j}\right] \qquad \text{(eqn 4.14)}$$

There are two fundamental assumptions behind the heterogenecus force attrition equations 4.13 and 4.14:

(1) The attrition-rate effects of various different enemy weapon-system types against a particular friendly target type are additive,

(2) The loss rate of a particular friendly target type to each enemy weapon-system type is proportional to the number of enemy firers of that particular enemy-firer type.

Although assumption (1) is fairly restrictive (it means that there is <u>no</u> <u>mutual</u> <u>support</u> among different weapon-sytem types, i.e. no synergistic effects), the author does not know of any U.S. heterogeneous-force model that does not use it. [Ref. 13: p.18]

The formulaticns described above lay the foundations for detailed Lanchester-type attrition models. The equations for heterogeneous forces make for very complicated differential equations that, for the most part, are impossible to solve explicitly. The state equations and definitions of force posture for victory that were present in homogeneous forces are no longer possible. The 'solution' of the complex attrition equations entails the use of a discrete time step integration. The time step is used to multiply the attrition rates and weapon numbers. The result, the actual attrition for that period, is subtracted from the value of the X and Y forces from the previous step. The process is continued, with the aid of a high speed digital computer, until one force is defeated or until a breakpoint is reached. A breakpoint is a prior determined point at which one of the forces breaks off the engagement due to reaching a certain minimum in his force strength. Actual operational models are much more complex than described here but the conceptual approach used is valid and should give the reader an appreciation of the parameters and methodology used in detailed Lanchester-type combat attrition.

5. Development of Operational Models

Combat is a very complex process that contains many interactions that are difficult to describe or even understand. The paradigms discussed so far are foundations for the underlying attrition processes of combat but, by themselves, cannot be used to model combat. To develop operational models, a more complete look at the total of the combat processes must be considered.

Considerations must be given to operational factors such as supplies on hand and ammo expenditure rates. The overall quality of troops in regards to experience, training and possible fatigue or motivational aspects are important. Rates of movement in relation to terrain types, weather and attrition are important considerations in an operational model.

It is obvious that the relations discussed above drive an operational model into a very complex process that must consider relationships between the different factors in detail. A method used to alleviate some of the complexity of operational models is to make certain assumptions about the detail of lower-level combat so more emphasis can be placed on the relationships of operational factors in the combat processes. This method involves 'aggregating' the weapons of a force into a larger entity that has the implied strength of all weapons composing it.

Unfortunately for small-arms, the processes used to determine outcomes are based first on attrition and then on movement. The point is that small-arms affect movement more so than attrition. Since small-arms do not play a large roll in attrition, they are not represented in the movement phase. Examination of chapter II and appendix A reveals that small-arms play a vital role in movement directly though. An attacking force can move through a defended position much faster if a successful reconaissance was conducted and if the AT weapons are suppressed. Small-arms are the key here.

B. AGGREGATED MODELS

The detailed Lanchester-type equations discussed earlier model combat in a microscopic manner. The attrition reflects the internal dynamics of combat on a weapon to weapon basis. Another approach for modelling attrition, commonly called the Firepower Score, is to represent it in a macroscopic fashion. Rather than model attrition in a weapon by weapon basis, the value of the weapons systems of a force are added up to give an overall "combat capability" index of a force. This combat capability is compared to the capability of an opposing force and the act of combat causes attrition to the capability index rather than the individual weapons directly. Losses to individual weapons are determined through some means of disaggregation based on the overall loss to the capability index.

Whether the combat model is a detailed Lanchester-type model or of the Firepower Score approach, "a key observation is that at some point in modelling, detailed description of the interactions between physical things ceases and estimation of relationships based on derived capability measures begins." [Ref. 15: p.ii]

TABLE VII

DETERMINATION OF A FIREPOWER INDEX FOR A COMBAT UNIT

WEAPON	NUMBER	FIREPOWER SCORE	TOTAL CONTRIBUTION TO FIREPOWER INDEX
RIFLE M-16, 5.56mm	6,000	1	6,000
MG, M-60, .30 cal	150	6	900
MG, M-2, .50 cal	250	10	2,500
MORTAR, M-125, 81mm	50	20	1,000
HOWITZER, M-109(SP), 155mm	50	40	2,000
HOWITZER, M-110, 8"	8	30	240
TANK, M60A2	200	100	20,000
TOTAL FIREPOWER INDEX			32,640

Table VII is an example of the Firepower Score approach. Firepower scores are used to denote the relative value of a specific weapon while a firepower index is the summation of all firepower scores of all weapons or the overall strength of the total force. The firepower score starts out as some statistical capability of single-round lethality times the ammunition expenditure rate. But varying degrees of subjectivity are involved in the final score given. [Ref. 2: p.87]

The numbers and scores for the weapons in Table VII are definitely open for discussion. This is one of the underlying arguments to this approach. The main point here is the concepts not the particular numbers and score.

Whether known as weapons effectiveness index (WEI), weapons unit value (WUV), firepower potential (FPP), or any other of a number of names, firepower indices have been used for at least thirty years by military planners. In division-level combat and above, firepower indices are used as a representation of unit strength to compare against an opposing force's index to determine outcomes of combat processes as shown in table VIII. [Ref. 2]

TABLE VIII
USES OF FIREPOWER SCORES

(1) determine engagement outcomes
(2) assess casualties
(3) determine FEBA movement
and (4) determine tactical decisions.

Once the firepower index of a unit is determined, as in table VII, it is compared to the firepower index of the opposing force to get an attacker-defender force ratio. The force in Table VII has a firepower index of 32,640. If an attacking enemy were to have a firepower index of 146,880, then the attacker-defender force ratio (A/D) is 4.5. An example of the casualty-rate curves used in the Atlas Model is shown in figure 4.4. Notice the different attrition rates depending on force ratio, type of engagement, and how fortified the position. [Ref. 2: p.97]

The firepower score approach to combat attrition modelling has received a fair amount of criticism. It is not as intuitively appealing as a detailed Lanchester-type model, but it is much easier to use in large level combat. This easier use is dc to less parameters to input making it easier tc; build, get data, make computations, and to analyze results. Chapter V explores the concepts of another aggregation approach. While eventually this other approach is a type of firepower score, the methodology used to arrive at the score is uniquely known as the antipotential potential method.

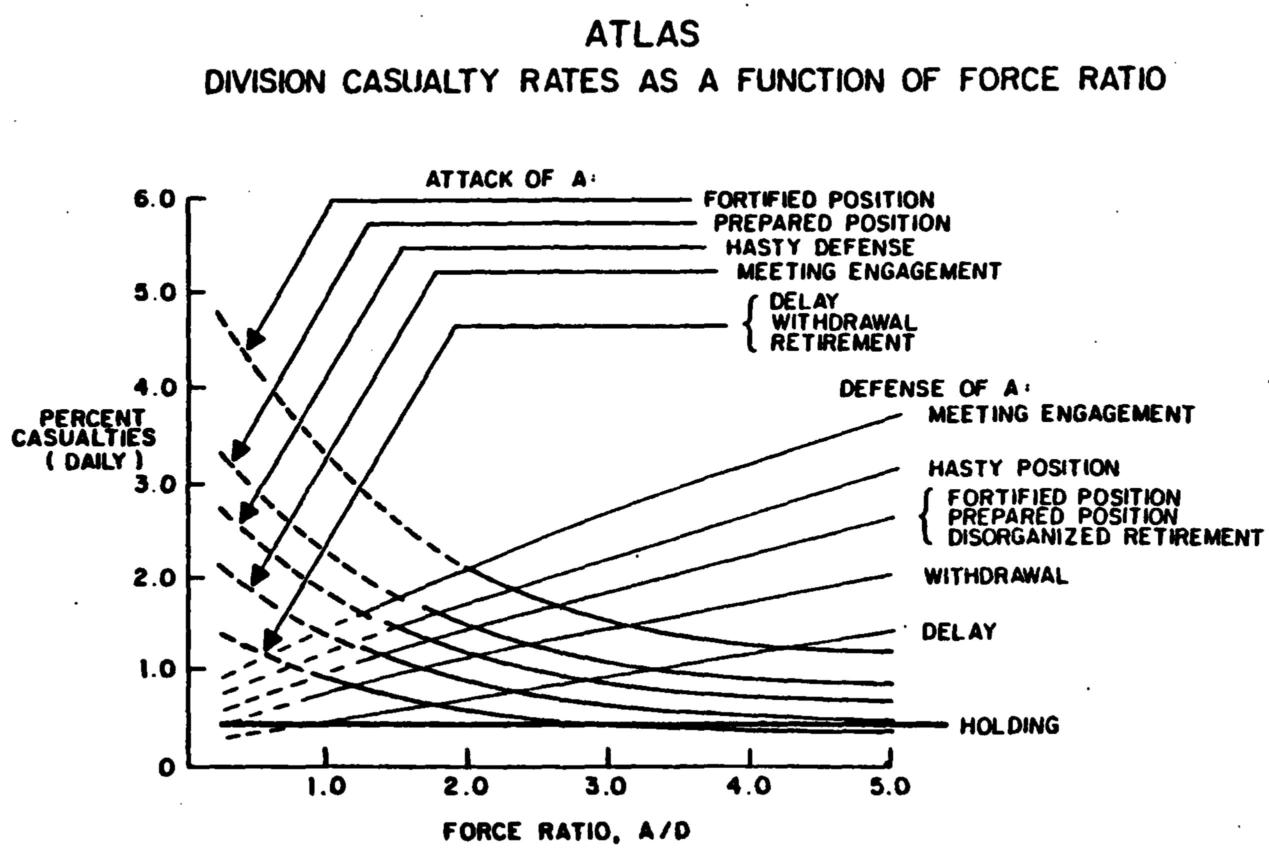

Figure 4.4 TYPICAL CASUALTY-RATE CURVES USED IN ATLAS.

V. REPRESENTATION OF ATTRITION IN IDAGAM

Discussion of an operational model will highlight the points of the previous chapters. Small-arms have not lost any of their value to the maneuver commander in the combat situation. They are just appearing to lose it to a modelling technique that is forced to evaluate combat in an aggregated fashion.

The Institute for Defense Analysis Ground-Air Model (IDAGAM) is a deterministic computer model of theater level conventional combat representing two opposing ground and air forces. IDAGAM was initially produced for use by the Studies, Analysis and Gaming Agency, Organization of the Joint Chiefs of Staff (SAGA,OJCS). The model was the principle model used by SAGA in analyzing war plans for conventional land combat.

The model used now by SAGA is the Integrated Battlefield Iterative Model (INBATIM). INBATIM is the model used in the Tactical Force Capability Analysis (TFCA), the major U.S. joint analysis of conventional combat capability. INBATIM evolved from IDAGAM and the antipotential potential approach described here for IDAGAM is essentially the same as that used in INBATIM. INBATIM has dropped the computation of close air support from the ground model and encorporates it in the air portion. INBATIM aggregates weapons according to classes. There are twelve classes starting with small arms as class I. [5]

The emphasis of this chapter is on the attrition calculations most often used in IDAGAM for ground combat. Since IDAGAM is a theater level model, there are many submodels of

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[5] Information on INBATIM is taken from a conversation with LTC. J.M. Cummings of SAGA,OJCS.

importance to the overall model. Air combat, logistics, and theater control are very critical to the running of the model but there is no need to discuss them in detail here as the effects of small-arms are not directly related to them.

Figure 5.1 shows the organization of the ground combat model used in IDAGAM. The discussion of the model will concentrate on computing losses of weapons and personnel as these are the attrition processes where the effects of small-arms are imbedded. The scheme for computing attrition is dependent on the "Method for Computing Force Ratio" (MCFR). Although there are 13 choices for setting MCFR in IDAGAM, the main use of the model by SAGA used MCFR 9 and will be the one discussed here. [6] The method (MCFR=9) involves the use of antipotential potential with value base scaling. [Ref. 16: p.30]

The antipotential potential value of a ground weapon is the capability of that weapon to destroy the value (potential) or killing capability of another ground weapon. The attrition calculations involve determining both losses of personnel and weapons. Both "potential" and "actual" losses are considered. The actual number of weapons lost is proportional to the potential number of weapons lost. The proportionality constant is based on casualties suffered by the force or upon value lost by the force.

The scheme for computing attrition is carried out as indicated in Table IX. [7] The potential number of weapons lost by type is a function of: total number of weapons of that type, allocation of fire of all enemy weapons at the weapon type, and the rate at which each of the enemy weapons

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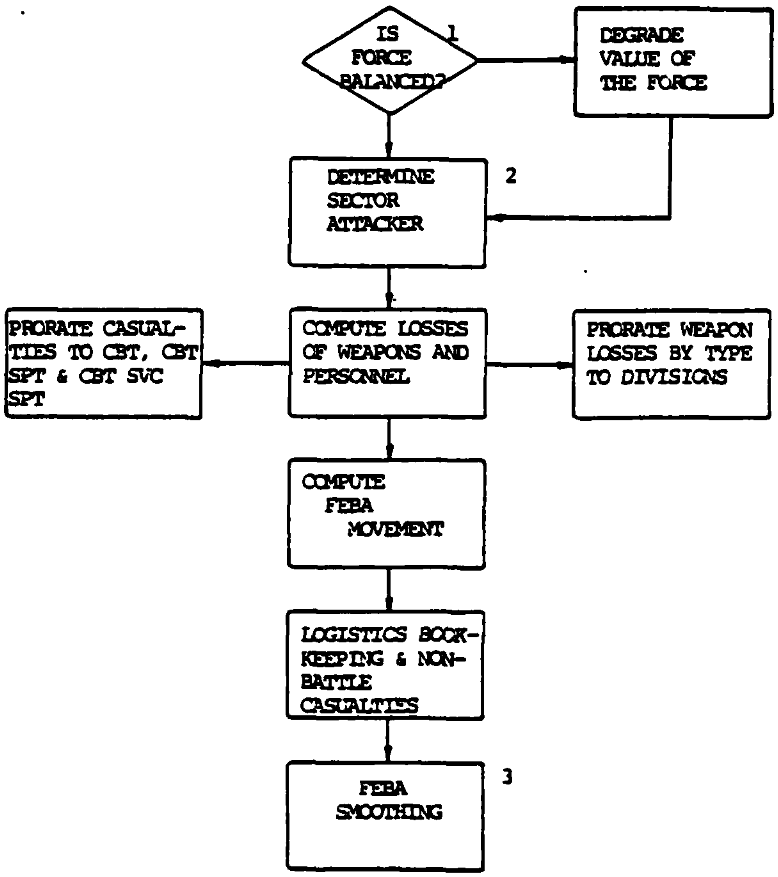
[6] For a complete coverage of the 13 methods, see reference 16.

[7] The scheme shown is for value based scaling, that of using a relative 'value' of one weapon versus another. Other methods are available, but value based is the one most often used.

THE GROUND COMBAT MODEL



[1]By force balance, the model is determining whether a proper mix of weapons exists, i.e., is it a balanced combined arms organization?

[2]Sector attacker is determined by comparing the force ratio in the sector to input values for determining attacker/defender. If no one can attack, a holding posture exists and attrition calculations are then computed based on neither side attacking.

[3]FEBA smoothing here means that both attacker and defender must withdraw if their flanks are excessive with respect to sector frontage.

Figure 5.1 THE GROUND COMBAT MODEL.

kills a weapon of that type in a day. Also included are aircraft and air munition loads and their respective rates of kill. This is basically a modified Lanchester-type Square Law equation. [Ref. 16: p.32]

TABLE IX

ATTRITION SCHEME FOR VALUE BASED SCALING METHOD

1) Compute Potential Number of Weapons Lost by Type

2) Compute Casualties Per Weapon Lost By Type Weapon

3) Compute Value Lost By the Force

4) Compute Actual Weapons Lost By Type

5) Compute Total Casualties Which Will Be Equal to the Sum Over All Weapon Types of the Product of Number of Weapons Lost and the Number of Casualties Associated With the Loss of That Weapon Type

The fractional allocation of fire is a sensitive input to *IDAGAM*. *Given a* "standard" force composed of various weapon types, the allocation of fire is the percentage of time a particular weapon type will engage each of the various weapon types of the opposing force. The allocation may be from a judgmental Delphi technique or it could be the result of examining the outputs from high resolution models to see how fires were allocated. Unfortunately, current models for this purpose are of limited use because the command and control functions and movement and firing are not modelled. [Ref. 16] A rigorous mathematical treatment of the fire allocation scheme used in IDAGAM can be found in reference 17.

The mathematics for this scheme is well documented, but one is still faced with the controversial problem of a historical database with questionable alterations from judgmental sources. Regardless of the sources, one can be sure that small-arms again play the "hidden" role of controlling movement.

Figure 5.2 depicts the attrition computation scheme for IDAGAM when the MCFR=9, the most widely used antipotential potential method. [Ref. 16: p.53]

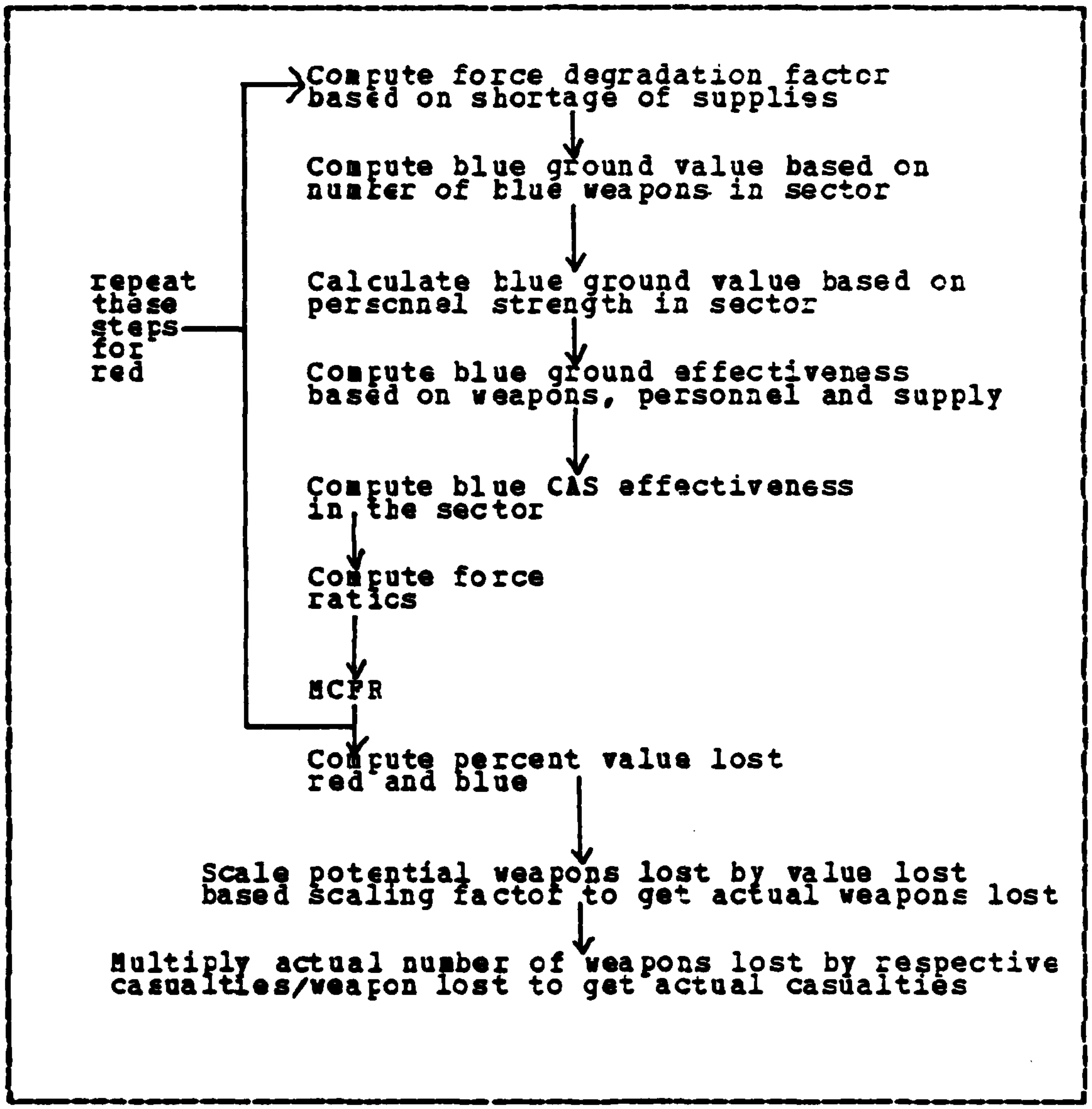


Figure 5.2 COMPUTATION OF WEAPON AND PERSONNEL ATTRITION.

The following sections elaborate on the steps found in Figure 5.2.

A. DEGRADATION FACTOR DUE TO SHORTAGE OF SUPPLIES

The number of days of supply on hand is equal to the number of tons of supplies in the sector, divided by the number of people in the sector times the planned daily consumption rate for the force plus a summation over all weapon types of the number of weapons times the planned daily supply consumption rate for the weapon. The supply effectiveness function is basically a linear function ranging from 0 effectivenss for no supplies on hand , to an effectiveness of 1.0 for 3 or more days of supplies on hand. [Ref. 16: p.61]

B. GROUND VALUE COMPUTATION IN VALUE BASED SCALING

The derived value of a weapon is proportional to the total rate at which the weapon is destroying the value of

$$\text{Value}\left[\begin{array}{c}\text{blue weapons}\\\text{of type j}\end{array}\right] \propto \sum_{j} \left\{\begin{array}{c}\text{Rate at}\\\text{which i}\\\text{kills red}\\\text{weapons of}\\\text{type j}\end{array}\right\} \left\{\begin{array}{l}\text{value of}\\\text{a red type}\\\text{j weapon}\end{array}\right\}$$

Figure 5.3 VALUE OF A WEAPON.

enemy weapons. (see figure 5.3). The kill rate of an i shooter firing at a j target is proportional to the fire allocation of that firer at that target times the input value of the i shooter firing at the j target in a particular posture. These rates are derived from historical investigations of past battles, based on ammo expenditure and number of kills with judgmental factors for how one percieves future combat to be differant from the past. The proportionality is $1/\lambda$ where λ is the eigenvalue of the matrix of kill rates for each side summed over all weapon types. The total value of the force is the summation of all the weapons in the force of each of the weapon type's value times the corresponding number of weapons of that type in the force. [Ref. 16] *

C. GROUND VALUE BASED ON PERSONNEL STRENGTH

The effectiveness of a force due to personnel strength is a function of the fraction of authorized strength present in the force. (FIG 5.4)

$$\text{EFFECTIVENESS} = f\left\{\frac{\text{TOTAL ACTUAL NUMBER OF PEOPLE IN ALL DIVISIONS IN SECTOR}}{\text{TOTAL AUTHORIZED (TOE) STRENGTH OF ALL DIVISION IN SECTOR}}\right\}$$

Figure 5.4 EFFECTIVENESS DUE TO PERSONNEL.

If E* is the effectiveness described above and V* is the total value of the force, computed as in section B above, then the value based on personnel strength of a type-d division on defense (attack) in a particular posture is defined as their product. [Ref. 16]

(Value Based On Personnel Strength) = E*V*.

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*See reference 16: p.67 for a more complete look at the mathematics of the eigenvalue problem.

D. DETERMINATION OF TOTAL GROUND VALUE

The ground value of a division is defined as the minimum of the total value of the force or of the value based on personnel strength, (see figure 5.5).

$$\min \left\{ V^*, \begin{array}{l}\text{value based}\\ \text{on personnel}\\ \text{strength}\end{array} \right\}$$

Figure 5.5 GROUND VALUE.

The rationale used here is to insure that there is a balance between personnel and weapons, i.e., that the available weapons are manned by the available personnel. A man must have a weapon to fight with as a weapon must have a man or men to fire it.

The total ground value is then computed as in figure 5.6. The total ground value is a sumation over all divisions of the value of the division times the number of that type of division and an appropriate supply shortage factor.

$$\left\{ \begin{array}{l}\text{TOTAL GROUND}\\ \text{VALUE ON DEFENSE}\\ \text{(ATTACK) IN A}\\ \text{PARTICULAR POSTURE}\end{array} \right\} = \sum_{d} \left(\begin{array}{l}\text{VALUE OF}\\ \text{A TYPE-d}\\ \text{DIVISIONS}\\ \text{IN SECTOR}\end{array} \right) \left(\begin{array}{l}\text{THE NUMBER}\\ \text{OF TYPE-d}\\ \text{DIVISIONS}\\ \text{IN SECTOR}\end{array} \right) \left(\begin{array}{l}\text{SUPPLY}\\ \text{SHORTAGE}\\ \text{DEGRA-}\\ \text{DATION}\\ \text{FACTOR}\end{array} \right)$$

Figure 5.6 TOTAL GROUND VALUE.

The interpretation of the total ground value in the sector is the potential value that it can destroy (MCFR=9). It is a function of number of weapons, number of personnel and supplies on hand as well as red side parameters. [Ref. 16: p.71]

E. COMPUTATIONS OF TOTAL AIR VALUE (CAS) IN SECTOR

The computations for total air value parallel those for total ground value. Air munition types are used in place of ground weapon types, fractional allocation of munitions at a specific target type, and the input value of an air munition against a specific target type are similar to the ground value use. [9]

F. COMPUTATION OF FORCE RATIO AND FRACTIONAL VALUE LOST

The force ratio if no CAS sorties are flown is computed as in figure 5.7 (MCFR=0).

$$\text{FORCE RATIO} = \frac{\text{TOTAL RED GROUND VALUE IN SECTOR}}{\text{TOTAL BLUE GROUND VALUE IN SECTOR}}$$

Figure 5.7 FORCE RATIO.

The fractional value lost daily is a function of force ratio and engagement posture. Figures 5.8 and 5.9 illustrate examples for losses to the attacker and defender. These casualty rate curves are derived from those used in the ATLAS model (see FIG 3.4). These functions have been refined, over time, based on judgement, to reflect a higher intensity of combat with modern weapons systems. There is

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[9]See ref 16: p.72 for a detailed discussion of computation of Total Air Value.

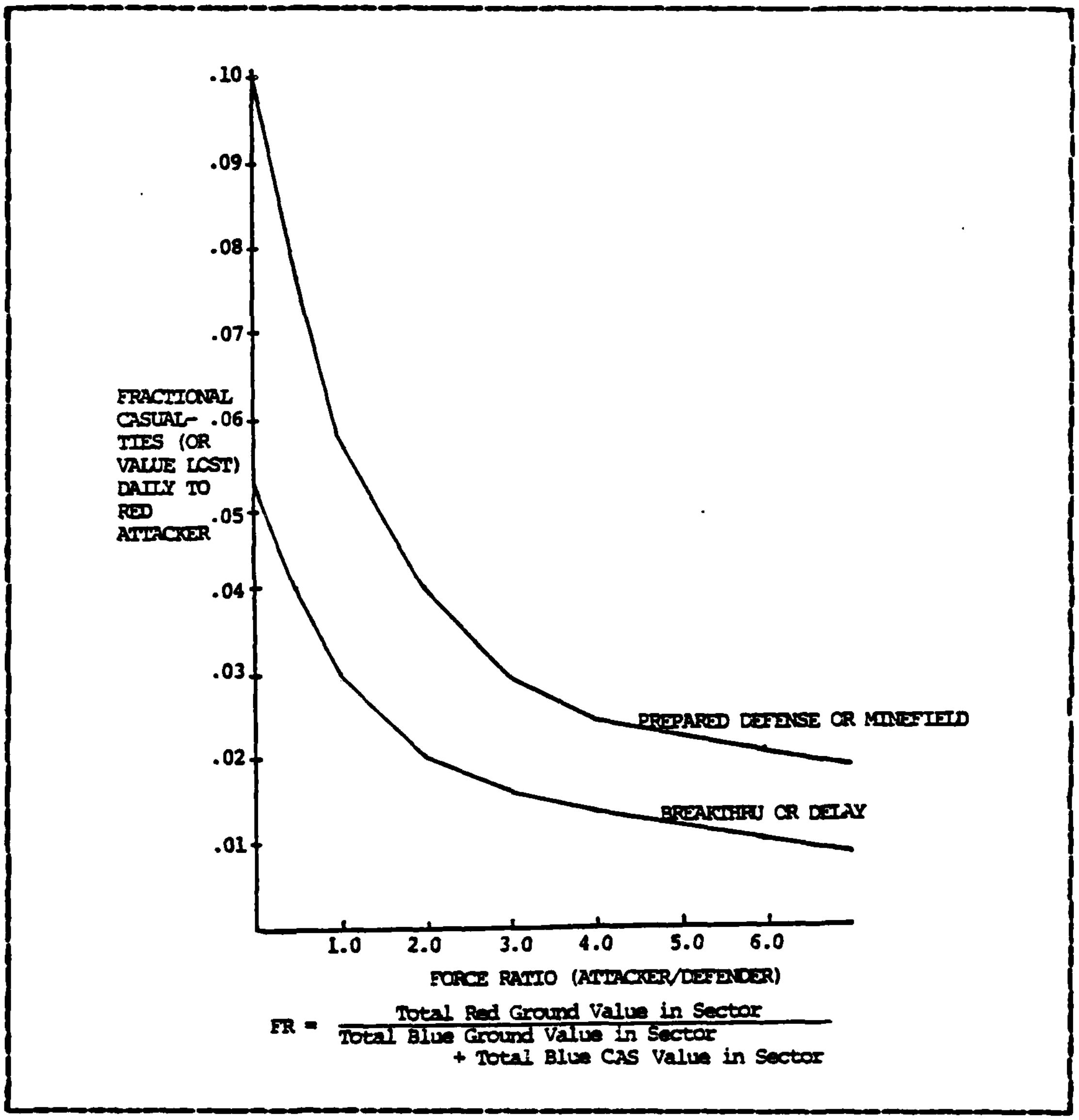
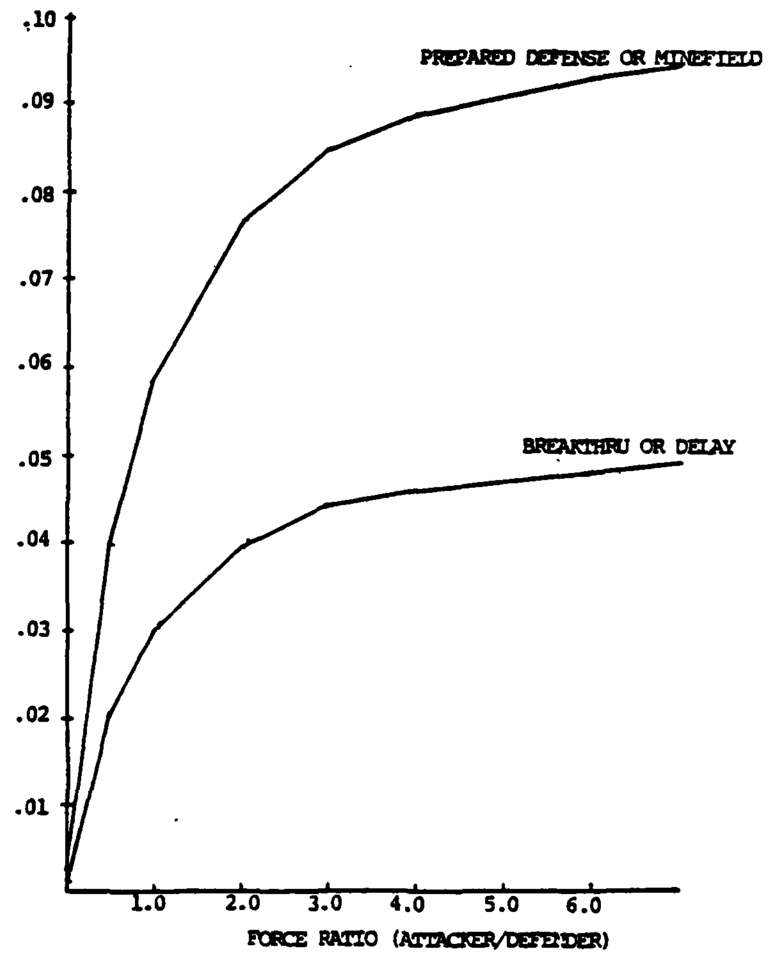


Figure 5.8 CASUALTY FUNCTION RED ON ATTACK.

still considerable controversy regarding the historical base of WWII, with changes from the Middle East War, representing future conflicts. The question of how to change the casualty rate curves to represent a more intense combat environment still appears to warrant attention. [Ref. 16: pp.73-78]



$$FR = \frac{\text{Red Total Ground Value in Sector} + \text{Red Total CAS Value in Sector}}{\text{Blue Total Ground Value in Sector}}$$

Figure 5.9 CASUALTY FUNCTION BLUE ON DEFENSE.

G. SCALING, COMPUTATION OF CASUALTIES AND WEAPON LOSSES

When MCFR=9, the fractional value lost is multiplied by the total ground value and divided by the the potential value lost to form the scaling ratio. The scaling ratio is then multiplied by the potential number of weapons lost of each type to the actual number of weapons lost of each type in a sector:

$$\left[\begin{array}{l}\text{ACTUAL NUMBER}\\ \text{CF BLUE TYPE } i\\ \text{WEAPONS LOST}\\ \text{IN SECTOR}\end{array}\right] = \frac{\left(\begin{array}{l}\text{FRACTIONAL VALUE}\\ \text{LOST TO BLUE IN}\\ \text{SECTCR}\end{array}\right)\left(\begin{array}{l}\text{TOTAL BLUE}\\ \text{GROUND VALUE}\\ \text{IN SECTOR}\end{array}\right)}{\left\{\begin{array}{l}\text{POTENTIAL}\\ \text{NUMBER OF}\\ \text{BLUE TYPE}\\ i \text{ WEAPONS}\\ \text{LOST IN}\\ \text{SECTOR}\end{array}\right\}\left\{\begin{array}{l}\text{VALUE OF THE}\\ \text{BLUE TYPE } i\\ \text{WEAPONS}\\ \text{CONSIDERING}\\ \text{BLUE IS ON}\\ \text{DEFENSE}\\ \text{IN A PARTIC-}\\ \text{ULAR POSTURE}\end{array}\right\}}\left\{\begin{array}{l}\text{POTENTIAL}\\ \text{NUMBER CF}\\ \text{BLUE TYPE}\\ i \text{ WEAPONS}\\ \text{LOST IN}\\ \text{SECTOR}\end{array}\right\}$$

In the value based scaling method, the total number of casualties is computed after the actual number of weapons lost is computed. The total number of casualties in a sector is taken to be the product of the actual number of weapons lost of each type and the corresponding number of casualties associated with the loss of each weapon type. (see FIG 5.10) [Ref. 16: p.82]

$$\left\{\begin{array}{l}\text{TOTAL NUMBER}\\ \text{OF CASUALTIES}\\ \text{IN SECTOR}\\ \text{TO BLUE}\end{array}\right\} = \sum_{i}\left(\begin{array}{l}\text{ACTUAL NUMBER}\\ \text{OF BLUE TYPE } i\\ \text{WEAPONS LOST}\\ \text{IN SECTOR}\end{array}\right)\left(\begin{array}{l}\text{NUMBER OF}\\ \text{CASUALTIES}\\ \text{ASSOCIATED}\\ \text{WITH THE}\\ \text{LOSS OF}\\ \text{EACH BLUE}\\ \text{TYPE } i\\ \text{WEAPON}\end{array}\right)$$

Figure 5.10 ACTUAL NUMBER OF CASUALTIES.

The input for the number of casualties associated with each weapon loss is a critical value and again controversial with historical data and judgement on increased intensity of modern combat.

IDAGAM has problems similar to those of the detailed models of the earlier chapters in the representaton of small-arms effects. IDAGAM has nice mathematical relations set up to handle the modelling of combat with all sorts of submodels, but it still relies on a casualty function that is historical in nature with changes as perceived by the model builder. It is not the intention of this thesis to degrade a historical base of these models. It is important that models be validated and history is the best way of doing that right now. It must be remembered, however, that small-arms played a big role in the past historical battle and will play a large role in the next actual battle. One must be careful not to forget them in our models or "educational battles."

VI. DISCUSSION

Chapter II and appendix A point out that small-arms have certain well defined missions and perform certain functions vital to successful combined arms combat. An examination of chapters IV and V reveals that the important functions for small-arms of security, personnel safety, terrain denial, breaking up opposing forces, and preventing dismounted infantry from clearing obstacles are not explicitly represented in IDAGAM or other current models. The complexities of low-level combat are so great that current models designed for theater-level combat must aggregate forces so a more manageable level of combat is achieved. The assumptions used to aggregate the individual weapons are the very ones that contain the value of small-arms.

The quantized values given to tanks or artillery in an aggregated model are all based on assumptions that adequate security is provided by small arms. Movement rates given for attacker/defender postures in different terrain all assume small-arms helping or hindering the movement. The probabilities of kill for tank and antitank systems all are based on experience in which small-arms play a vital role in preventing access to terrain and channelizing the opposing force. The values given to larger weapons systems are not totally a representation of a single large weapon, but are a representation of that single large weapon supported by a complement of small-arms.

All models need to be validated by some means. There has to be some standard against which to check a model to insure that it generates results that are reasonable and as real to life as possible. In the case of combat models, the validation takes place through historical analysis of past battles, with judgemental factors for how one perceives past warfare to be different from the present or future.

The basis for determining such things in the models as relative values of weapons systems, movement rates and overall attrition factors, is based on historical interpretations. All of these historical and judgmental interpretations have and had small arms present. There is no data base, historical or otherwise, on which to base a 'battle' with no small arms. This of course would be ludicrous but is essentially the question one is asking when trying to define the value of small-arms in a combined-arms scenario.

COL. Tevor N. Dupuy is known for his historical studies that define attrition rates such as those used in the ATLAS model and further refined for IDAGAM. COL. Dupuy has developed tables of Combat Multipliers for various parameters of battle such as weather, terrain, surprise, and others for use in his Quantified Judgement Model. A table on defense terrain multipliers defines values ranging from 1.05 for flat-bare, hard ground to 1.55 for rugged-semiwooded ground. [Ref. 18]

A logical extension to COL. Dupuy's work, tying in with observations from the National Training Center, would be to define the value of small arms as multipliers from the standpoint of making terrain more impassible through the protection of obstacles and channelizing of infantry. For example, if a piece of terrain had a value of 1.3 for a hasty defense, it might be 1.4 for a defense that placed out good obsacles and possibly 1.5 or 1.6 if those obstacles were protected from both reconnaisance and clearing by small-arms fire. This concept appears to warrant future attention.

VII. FINAL REMARKS

The total contribution of small-arms to modern combat is not currently represented explicitly in existing aggregated-force models. The various effects of small-arms discussed in this thesis simply are not considered. At best, they are implicit in the casualty-assesment routines of aggregated force models. In other words the historical development of attrition rates and movement rates of current models all have unstated but assumed small-arms support.

Synergism, the actions or threat of one weapons system or systems causing another weapons system to achieve a kill, is what makes the combined arms team a force with a value greater than the sum of its parts. Unfortunately, empiracal data to give definition to synergism at the heart of the battle is difficult to obtain.

Small-arms are every bit as vital to a successful battle today as they were in the Civil War. New weapons sytems and tactics have forced some evolution on the use of small-arms and the small-arms themselves are evolving to meet the challange of a technically advanced adversary. With the threat and friendly weapons systems advancing at a rapid rate, it would be a disastrously easy mistake to let small-arms advancement and employment fall behind.

APPENDIX A

NATIONAL TRAINING CENTER OBSERVATIONS

DEPARTMENT OF THE ARMY
U.S. ARMY COMMAND AND GENERAL STAFF COLLEGE
FORT LEAVENWORTH, KANSAS 66027

REPLY TO ATTENTION OF

ATZL-SWU-N 16 February 1984

SUBJECT: Use of Infantry at NTC

Commandant
Naval Post Graduate School
ATTN: CPT Larry Lane
Presidio of Monterey, CA 93940

1. Reference FONECON between you and LTC Crowley about MG/rifle data from National Training Center (NTC). We do not have analytic data on use of these weapons systems suitable to support your project.

2. Problems with collecting such MG/rifle data are:

   a. Lack of links between all dismounted soldiers and the computer.

   b. Smaller numbers of OPFOR infantry than would be available in a Soviet formation.

3. In spite of these limitations, infantry is critical to the conduct of mobile operations in the desert. An enclosed staffed article points out roles of infantry in the defense. In the offense, a dismounted infantry capability is required to:

   a. Clear danger areas and obstacles.

   b. Attack OPFOR positions too well defended to be assaulted by mounted forces.

   c. Conduct dismounted operations under limited visibility conditions.

4. Operations at the NTC continue to prove the absolute requirement to have well-trained dismounted soldiers available to work as members of the combined arms team in any normal tactical mission.

1 Encl
as

JON C. STILLMAN
Colonel, Infantry
Director, UTSD

ENCLOSURE FROM ABOVE LETTER

This issue of Training Notes will present tactics and techniques that have proven to be effective for defending a single company battle position. We will highlight and expand on what worked at the NTC.

MAJOR LESSONS

Units training at the NTC quickly learn four major lessons about conducting defensive operations. Speed of OPFOR advance: OPFOR technique, like those of the Soviets, do not emphasize terrain driving or bounding overwatch. Instead, techniques consistently used are rapid movement to an assault line, deployment, and then assault. This means the OPFOR moves considerably faster than units using American tactics. Therefore, defending units must act, mass fires and shoot quickly. There isn't a lot of time for decisionmaking or maneuver; the battle can be won or lost in the first 30 minutes from the time the OPFOR main attack begins. Effective use of obstacles is critical and can allow the commander time to reposition forces so that the OPFOR is defeated.

Obscuration of the battlefield Obscuration is the normal condition for an attack. The OPFOR normally tries to place smoke on or near the Blue positions and units to hide his movements. Additionally, desert dust conditions, obscuration caused by impacting indirect fires, and use of on board smoke generators cause OPFOR trailing vehicles within formations to be hidden from view.

Initially, units select weapon positions, sectors of fire and obstacle locations for full visibility conditions. Successful units realize that defensive positions must be set up to work both in full and limited visibility with minimal adjustments. They start to position weapons and obstacles to meet both conditions. This means weapons are placed closer to enemy avenues of approach, or where they can quickly move to limited visibity positions; obstacles are sited closer to weapons, flanking fires are emphasized, and more weapons are initially allocated to cover approaches the OPFOR may use under limited visibility conditions. The key point on identifying limited visibility approaches is that when an enemy attacks during limited visibility, he must attack along an axis which simplifies navigation, command, and control.

Limited visibility as a normal condition probably applies to any future battlefield.

Skillful positioning of weapons: AT weapons must be carefully sited to provide cover, mutual support, dispersion, flanking fires, and to allow movement. Obvious terrain must be avoided. Every favorable fold of all other ground must be used. Use of dug-in or hide positions may be required. Units too often tend to go to high ground even when it does not provide good weapons positions, or covered movement routes.

Weapon positions should always be checked from the enemy's side prior to the battle to ensure proper cover, concealment and siting. If the situation permits, a vehicle traversing likely enemy avenues of approach can assist in determining exposure. This is especially important for TOWs and Dragons. From this check, weapons are repositioned as necessary.

OPFOR use of recon: OPFOR attacks typically begin with a nighttime reconnaissance effort to find obstacles and battle positions, and to gather information on the Blue forces. During this phase, obstacles are either breached or bypass routes found and marked. Units quickly learn that this reconnaissance effort must be stopped and that obstacles must be guarded to prevent neutralization. They should be checked at first light to ensure breaches haven't been made. Local security, movement of direct fire weapons to cover obstacles at night, and readiness of a reaction force to destroy enemy recon elemnts that penetrate the scout screen are key to defeating an enemy attack. Be ready.

USE OF MECHANIZED INFANTRY

Some of the most important lessons that come out of NTC operations are on the effective use of infantry. Here are some:

Infantry battle positions: Mech platoons do not defend battle positions using the mounted technique nor do they fire the Dragon from the APC. Units have found that both of these tactics found in FMs 7-7, 71-1 and 71-2 are ineffective; they cause APCs to be destroyed. When firing the Dragon or performing some other task that requires quick movement, infantry leaders stop the APC in full defilade, dismount the part of the squad needed and turn the APC around for quick exit. This technique allows quicker movement, is harder for the OPFOR to detect, and results in less exposure of the APC.

When defending a battle position, experience has confirmed the need to quickly and completely dig in. Fighting positions must have overhead cover. Placing dismounted infantry in naturally restrictive terrain such as wadis or steep hills makes this process quicker and easier.

Use of carriers: Bradleys haven't been used at the NTC yet. With the M113, units seldom position carrier teams with the dismounted elements as they found that the APCs are difficult to hide and give away the dismounted platoon positions. Rather, APCs are normally kept in hide positions and

Dragons are placed with the dismounted elements. Unfortunately, carrier teams are not used in a support by fire role. However this must be considered a MILES training problem. The M-2, 50 caliber machinegun can penetrate BMPs at close range and provide excellent suppressive effects against light skinned vehicles and personnel. The full use of carriers is not only valid but vital to get maximum fires on the enemy.

Mechanized Infantry platoon missions: Even in the relatively open Armor type desert terrain, infantry has proven to be a full fledged partner in the combined arms team. Good uses of infantry include:

-Providing security. OPs, ambushes, and patrols are positioned to detect and defeat OPFOR recon elements and to give early warning of OPFOR mounted or dismounted attacks.

-Building and protecting obstacles. Contruction of obstacles to slow down the OPFOR has proven to be a critical function. One engineer platoon per battalion is not enough in the normal time available. Infantry can and must help. Infantry must also be used to guard obstacles and is normally used to close lanes or gaps in obstacles. They must be fully prepared. When gaps/lanes must be closed, there isn't much time. The infantry element given this mission must be provided with demolitions (such as shape charges) or mines to close the gap or lane, unless the company or battalion plans to use FA-delivered scatterable mines. They must have a primary and at least one alternate means of communications with the company team to make sure the obstacle is closed quickly once the order is given. This element may stay behind to protect the obstacle from enemy recon/breaching efforts after the lane/gap is closed.

-Blocking enemy dismounted and mounted approaches. If AT fires can stop the OPFOR advance, the OPFOR will conduct a dismounted attack to destroy these weapons--normally moving through wadis or other rugged terrain. When availble, artillery or mortar FPFs should be planned on dismounted approaches and infantry positioned to block them. Dismounted infantry can also block mounted attacks. They can do this by being positioned in tank restricted terrain and placing Dragon and LAW fire on a high speed approach from the flank, or by blocking an enemy movement across trafficable terrain from well dug in positions protected by obstacles.

OTHER LESSONS LEARNED BY USING INFANTRY.

Place in restricted terrain Dismounted infantry must be placed in favorable positions. They should be on ground where they cannot be overrun by a mounted assault. Wadis, steep hills, protective minefields, or antitank ditches provide good protection.

Don't expose to long range fires and observations: As a general rule, a dismounted positon should not expose the infantryman at a range where he cannot effectively engage the enemy. While maximum range of the Dragon is 1000 meters, it should be positioned to fire at the flanks of armored vehicles, and so actual engagement ranges are less. The platoon should not be able to shoot (or be shot at) from more than this expected engagement range. Observation of greater ranges should be made by OPs located away from the battle position. Reverse slope positioning is often used, unless well covered positions, such as wadis, are available on the foward slopes.

Prepare for disengagement: When dismounted infantry is engaged, it is decisively engaged. The short range of infantry weapons means that when they shoot at any major OPFOR mounted attack, they cannot disengage unless the OPFOR has been stopped by massed fires and/or obstacles and covered routes of withdrawal are available; or unless the attacking OPFOR has been destroyed or pushed back. If the task force commander's plan is to disengage the infantry, the decision must be made early. If the foward position is not intended to be held, it has proven to be effective to send dismounted elements back to occupy and prepare subsequent positions while carrier teams with Dragons are used on the initial position.

Cover dismounted infantry with AT fire: The most dramatic examples of effective use of dismounted infantry have been in cases where the dug in infantry elements were attacking the OPFOR flanks and rear with close in fire while he was being engaged by TOWs and tanks in overwatch positions. This caused the OPFOR to fight in two directions. When this happened, the OPFOR was completely defeated and the dismounted infantry was extracted by the carrier teams after the battle.

USE OF TOWS/TANKS

Defensive "battles" at the NTC are won or lost by effective use of AT firepower. Maximum use of the mobility of these systems is critical. These weapons must be maneuvered to place effective fires on the enemy and to avoid enemy suppression. Here are some of the techniques used.

Disperse AT weapons: Initially, units tend to bunch up on dominant terrain. This makes command and control easier but makes you more vulnerable to preparatory fires; especially if the position occupied is obvious or if it has been located by OPFOR recon. It also makes it easier for attacking OPFOR tanks and ATGMs to spot and engage defending vehicles.

Use alternate positons: Alternate positions are necessary to allow TOWs or tanks to continue engagement if the enemy pinpoints the initial position. The need for alternate positions increases as engagement ranges decrease. In view of the normally rapid OPFOR advance, alternate positions must be close enough for quick movement, but out of the enemy weapon sight picture (50-75 meters). If there has not been time to locate or prepare alternate postions, as a last resort, the vehicle should at least pull out of the position after firing three or four rounds and then reoccupy it. This breaks up the enemy's sight picture.

Use supplementary positions: Supplementary positions are ones which allow weapon fire into a different area. To mass fires on the enemy, each company will normally be given one or more on order sectors of fire, engagement areas, or Target Reference Points (TRPs). Likewise the team commander normally assigns on order sectors of fire to his platoons. As in choosing alternate positions, rapid movement between primary and supplementary positions must be possible.

Prepare recon and rehearse routes between positions: Experience has shown that most losses take place during movement, so routes out of and between positions must have cover and concealment. If covered routes aren't available then use of smoke can provide some protection. Because the OPFOR puts suppressive fires on positions, vehicles normally must defend and move buttoned up and in MOPP 4. Crews must actually rehearse movements the same way. Here also the unit should conduct rehearsals while someone is watching from the enemy's side to see if vehicles are exposed. If they are, positons or routes should be changed.

Use of flank and rear shots: Flanks or rear engagements have proven far better than frontal ones. The OPFOR doctrine of a rapid advance makes it vulnerable to flank shots. A moving tank crew is generally oriented in its direction of movement. It can detect and engage a weapon to its front far easier than one to its flank or rear. Also its heaviest protection is on the frontal area. Units that have placed AT positions to engage the flank or rear of enemy formations have had some spectacular successes. There have been cases of a single tank destroying a whole OPFOR company!

Decide on disengagements early: In favorable terrain, OPFOR formations advance rapidly. Normal rate of movement is 300-400 meters per minute. If the team commander decides to move his unit, he must make that decison early enough to request permission from the battalion commander, get the word down through his chain of command, and get overwatch elements into position and indirect fires on the ground to cover the move. Rehearsal of moves are needed to find the actual times it will take to make the move. It helps to establish a measured "trigger line" on the ground or event (e.g., "When Team B gets to BP 34") to use a key to begin disengagement actions.

Fire control: Units are not initially using TRPs, engagement areas, near half/far half and other fire control techniques. This appears to be due to a limited use of MILES and/or limited experience at trying to defeat a large, rapidly advancing OPFOR during pre-NTC training. At Ft Irwin, units find that fire control is essential. Fires must be massed into the area where the enemy is advancing. At the same time these fires must be distributed across the enemy formation to avoid multiple firings at the same target. Units have found they must determine actual distances to the TRPs. This can be done by placing or using some object to serve as a range marker and by using a tank's or FIST's range finder. Knowing actual distance helps fire control and precludes firing at OPFOR vehicles out of range. Units also have found that marking Target Reference Points (TRPs) by chemical lights, with shielding to prevent them from being seen from the enemy's side, helps at night.

The use of the fire control techniques and the fire control matrix found in FM 71-1, pages 4-36 to 4-39, coupled with proper weapons positioning and designation of sectors of fire all are workable and necessary. Unfortunately, most units are untrained in these techniques. Although fire control and skill at weapons positioning are difficult tasks to master, units seldom fully develop this proficiency at the NTC. Good shooting, frequent boresighting of the MILES transmitter and control of fires is essential.

Perform early reconnaissance: Occupation and full preparation of a battle position, with careful siting of weapons, siting protective obstacles, establishing hot loops and all the other tasks that go into the development of a battle position, require many manhours. The company commander, platoon leaders and FIST chief must recon the battle pcstion and to select the position of weapons and obstacles. Selection of positions is easier if a tank and TOW vehicle are brought along. This can be done while the XO and NCO chain of command finish preparation and movement. When the company team main body arrives, it can be kept in a hide position to refuel, camouflage and have maintenance performed while leaders check positions. This technique can prevent unnecessary vehicle movement on the position.

Establish and enforce work priorities: Untrained units waste too much time getting started. The suggested work priorities found in FM 71-1, page 4-40, are good although they sometimes require modification. The important thing is that units have a practiced SOP for accomplishing all the tasks needed to defend a battle position. Selecting weapons positions, establishing sectors, laying hot loops, emplacing hasty protective minefields, preparing range cards, and camouflaging should be done automatically in a battle drill fashion.

Check positions at night: At night send a leader foward with a passive sight to check light dicipline from the enemy's side.

Counterattack preparation: Rapid movement of tanks to engage an enemy formation from the flank works. To do it you must plan and prepare. Select the positions that might be used and routes to them. Have the platoons rehearse. Secure the route and positions with OPs so that the counter-attacking force can move rapidly into position without the fear of running into an enemy force.

SUMMARY

This article has identified some of the techniques which leaders found effective in defending against the OPFOR at the NTC. The OPFOR is a demanding foe. He makes you pay for mistakes, just as a real enemy would in combat on any future battlefield.

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